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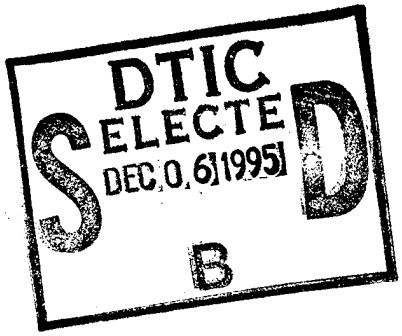
Pentagon New Heating and Refrigeration Plant Staffing and Training Plan
Final Report



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The New Heating and Refrigeration Plant (NHRP) for the Pentagon is expected to be operational in the first quarter of FY96 and replaces the original plant built in 1943. The NHRP utilizes advanced technology including digital control systems. This report identifies the specific staffing and training requirements for operation and maintenance of the new plant as well as identifies transitional issues to be planned for in moving from the operation of the old plant to the new one while assuring 24 hour/day — 7 days/week operation.

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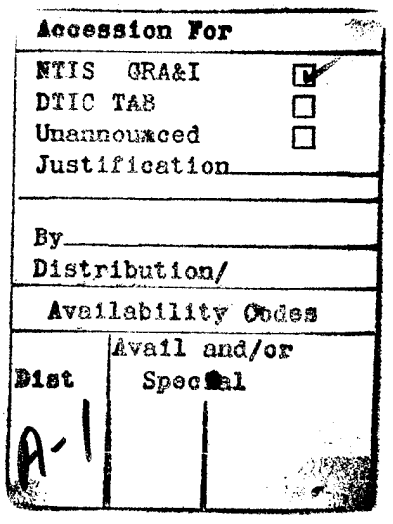

Executive Summary

The Department of Defense is building a new utilities plant, called the New Heating and Refrigeration Plant (NHRP), to replace the existing Pentagon Utilities Plant (PUP). The PUP, completed in 1943, has exceeded its design life and cannot reliably meet the Pentagon's utility needs. Scheduled for completion in FY96, the NHRP will incorporate computerized control systems as well as advanced technology for some of the equipment. The effective use of advanced technologies will require a substantially different combination of technical skills and management support to ensure successful operations. Also, because of the requirement for uninterrupted operation of the mechanical and utility systems for the Pentagon, the transition from the old to the new plant must be carefully planned.

The staffing and training plan we developed proposes that the NHRP be managed, operated, and maintained by a staff of 34 personnel, about half the number of positions at the PUP. Major maintenance and repairs will be done by the supplier of the equipment while it is under warranty; thereafter, those functions should be performed by plant staff or be contracted. The organizational structure of the NHRP staff will be similar to that at the PUP but streamlined.

While the size of the staff can be reduced, the skill levels must be increased. In particular, the use of distributed process controls, as well as digital controls on individual equipment, means that much of the staff will need to become knowledgeable about interfaces with digital equipment, and some staff will need advanced knowledge about distributed process control and communications systems. In addition, some NHRP personnel will have to be cross-trained to perform duties outside of traditional roles.

The recommended staffing levels and qualifications are comparable to those at similar facilities. The recommendations are based on a comparison of existing and new plant systems and equipment; no formal job or task analysis has been performed for the new plant. Although we have developed broad job qualification statements, we have not developed detailed screening criteria for staff qualifications.

We recommend that the plant manager and the operations and maintenance manager be assigned to start some 15 to 18 months before the plant is completed. The shift foremen should start about 6 months before plant completion, and shift personnel should be on site when start-up tests begin. Other maintenance

personnel should begin 2 to 3 months before the plant is completed, and administrative personnel, about 1 month before.

Training on individual pieces of plant equipment will be provided initially by the manufacturers and suppliers of that equipment. Much of that will be on-the-job training. Areas for which additional training should be provided are (1) a general orientation for all NHRP personnel of the plant, including an overview of the plant systems, followed by a walkdown of plant areas; (2) hardware and software development training; and (3) integrated, hands-on plant control training, preferably using a training simulator, for each member of the operating crew. To support the training program, documentation — particularly, detailed systems descriptions and lesson plans — needs to be developed using, as a basis, information supplied by the manufacturers. We recommend that a plan be put in place to develop systems descriptions, operating procedures, and training lesson plans on a schedule that will support start-up activities at the new plant.

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CHAPTER 1

Introduction

The Department of Defense is building a new utilities plant, called the New Heating and Refrigeration Plant (NHRP), to replace the existing Pentagon Utilities Plant (PUP). The PUP, completed in 1943, has exceeded its design life and cannot reliably meet the Pentagon's utility needs. To continue operation of the plant, DoD has had to lease equipment. The plant serves the Pentagon, Navy Annex (Federal Office Building 2), and Marine Corps Headquarters (Henderson Hall).

Scheduled for completion in FY96, the NHRP will incorporate advanced technology for much of the equipment and the computerized control systems. The use of advanced technologies will require a substantially different combination of technical skills and management support to ensure successful operations. Also, because of the requirement for uninterrupted operation of the Pentagon, the transition from the old to the new plant must be carefully planned.

The DoD tasked the Logistics Management Institute (LMI) to identify the specific staffing and training requirements for operation and maintenance of the new plant as well as identify the transitional issues that may affect initiation of operations at the new plant. MPR Associates is assisting LMI in this effort. This final report includes all of the products specified in the Task Order WH401.

To accomplish this task, LMI identified the existing plant systems and the operation, maintenance, and repair functions of the existing staff; identified the major systems, including the new technologies, in the new plant; and compared the new plant systems to the existing systems to estimate likely staffing needs of the new plant. Identification of staffing needs included development of an organization chart and, for each position, determination of the required level of education, on-the-job training, specific skills and knowledge, and licensing. In addition, we evaluated transitional needs (new plant testing and start-up) and developed a plan, including training needs, for the transition of plant operations and personnel from the existing to the new functions. Finally, we evaluated the extent and type of support services needed at the new plant and identified those that should be contracted.

Information regarding the distributed control system, its interfaces with the major equipment, and the associated operator interfaces is still being developed by the systems integrator, IMACS. That system and its interfaces will have a significant impact on training, operating procedures, and maintenance requirements for the new plant. Furthermore, the quality of the information and the acquired skills of the operations and maintenance personnel responsible for the system and its interfaces will have a direct bearing on the success and schedule

of plant start-up activities as well as on the subsequent reliability of new plant operations.

This report is organized as follows:

- Chapter 2 summarizes our conclusions and recommendations.
- Chapter 3 compares the physical arrangement, mechanical and electrical systems, and system controls of the existing and new plants. It focuses on the differences that will affect staffing requirements
- Chapter 4 presents the staffing plan for the new plant.
- Chapter 5 identifies training requirements and presents a training plan.
- Chapter 6 discusses support services.

Additional detail is provided in the appendices. Appendices A and B describe the systems and controls used in the PUP and the NHRP, respectively. Appendix C presents detailed job descriptions for positions in the new plant. Appendix D presents the results of a survey of staffing levels at other utilities plants.

CHAPTER 2

Conclusions and Recommendations

The principal functions of the PUP and the NHRP are the same – to provide the Pentagon, FOB 2, and Henderson Hall with steam, chilled water, and sewage/wastewater service and to distribute electrical power to those buildings. Therefore, the NHRP's systems will be similar to those used in the PUP; however, the NHRP will have more than double the amount of equipment. Specifically, it will have six 40,000-pound-per-hour boilers and ten 3,750-ton chillers. In addition, the NHRP will have five 3,600-kW emergency diesel generators.

Although the NHRP will have more equipment, operations generally should be easier, both because the physical arrangement of the plant is more compact and because all of the boilers and all of the chillers will be identical, which is not the case for the PUP. Automation also will facilitate plant operations.

We recommend a staffing level at the NHRP of 34 people, about half the number of positions at the PUP. This number is slightly higher than the staffing levels at comparable, nongovernment facilities, but we believe that it is reasonable since loss of service cannot be tolerated. The organization of the NHRP should be similar to that of the PUP, because the mission, objectives, and equipment are similar. However, the NHRP's organization will be streamlined.

While the size of the staff can be reduced, the skill levels must be increased. Of the differences between the PUP and NHRP, the use of distributed process controls in the NHRP will have the greatest impact, by far, on the qualification requirements of the NHRP staff. Some advanced knowledge of process theory and system dynamics is essential to interpret computer displays and to determine when process controls are malfunctioning. Skills for supporting the advanced digital control and communications systems also will be required. In addition, to provide the flexibility necessary with reduced staffing, some NHRP personnel will have to be cross-trained to perform duties outside of traditional roles. For example, electricians will be called upon to repair instruments or to start the diesel generators, and boiler operators may need to operate circuit breakers for the chiller motors.

The recommendations are based on a comparison of existing and new plant systems and equipment; and comparison with other similar facilities. The recommended staffing levels and qualifications are comparable to those at similar facilities. Although we have developed broad job qualification statements, we have not developed detailed screening criteria for staff qualifications.

The key events setting the recommended rate of personnel loading are chiller and boiler installation and testing, training, and testing of control systems. We recommend early start dates for the plant manager and the operations and

maintenance manager; 15 to 18 months before plant completion, or sometime in the third calendar quarter of 1994, would be appropriate. Starting early would enable the plant manager and the operations and maintenance managers to provide input on control room layout, arrangement and sequencing of annunciators, and selection of CRT screens. Shift foreman should be phased in thereafter, from December 1994 to May 1995. Shift personnel (operators and maintenance personnel) should be assigned to coincide with training and start-up tests, i.e., on site by the beginning of September 1995. Other maintenance personnel should begin 2 to 3 months and administrative personnel about 1 month before the plant is completed.

Most of the staff for NHRP likely will be drawn from the PUP staff, which should facilitate the transition to the new plant. The control system at the new plant is significantly different, however, and will have a major effect on plant operation. Thus, a broad-based training program that can accommodate the different experience and skill levels of the various personnel will be needed, along with screening criteria to ensure that adequate skills have been acquired.

The manufacturers and suppliers of the new NHRP equipment will provide operation and maintenance manuals, which are simple compilations of product literature by the various vendors, along with some on-site training on individual pieces of equipment. No provisions have yet been made to train staff in the operation and maintenance of plant systems, nor have system descriptions been prepared; those are equally important and are needed for the long-term operation of the plant. (Bell-BCI has indicated that it expects to cover plant systems during the training phase, but that training will be simply a review of the plant arrangement and system drawings; it will not include instructions in plant operation and maintenance.) We recommend that a plan be put in place to develop systems descriptions, operation procedures, and lesson plans on a schedule that will support the new plant start-up and training activities.

Senior plant management and shift supervisors should be brought on board well in advance of plant operation so they can direct their efforts to the preparation of operating procedures and manuals and to the development of a long-term training program. The systems operations manuals should be prepared under the direction of the plant manager by individuals skilled at such tasks.

Areas for which additional training should be provided are (1) a general orientation for all NHRP personnel of the plant, including an overview of the plant systems, followed by a walkdown of plant areas; (2) hardware and software development training for the electronic industrial controls mechanics and the computer systems specialist, covering a 6-month span from June to December 1995 and conducted periodically during the evolution of systems installation and tests; and (3) integrated, hands-on plant control training, preferably using a training simulator, for each member of the operating crew (currently scheduled operator training is limited to classroom teaching only and only for 10 people).

A simulator should be considered not only for training (both before start-up and for the long term) but as a platform for qualifying operators and for staffing

studies for operations. In addition, changes to software and screens identified in training activities could be made part of the control system debugging process if the simulator is obtained early in the system design evolution. This debugging process would be expected to identify first-time design implementation and minimize plant start-up delays and damage to equipment. Since involvement by the controls system designer and by the suppliers of the boilers and chillers would be necessary, the most opportune time for the development of the simulator is now. We recommend, as a minimum, that steps be taken as soon as possible to determine the cost and benefit of having a simulator for the NHRP.

CHAPTER 3

Comparison of Existing and New Plants

The principal functions of both the PUP and the NHRP are the same – to provide steam, chilled water, and sewage/wastewater service and to distribute electrical power to the Pentagon, FOB 2, and Henderson Hall. Both plants therefore contain similar systems and equipment. However, some features of the NHRP's physical arrangement, the numbers and ratings of its mechanical and electrical systems, and its system controls are sufficiently different from those of the existing plant to have an effect on staffing requirements. Those features are summarized below. Appendices A and B provide more detailed descriptions of the plants.

PHYSICAL ARRANGEMENT

Both the PUP and the NHRP have separate areas for the chillers, boilers, and electrical switchgear. However, the general arrangement in the new plant is more compact and amenable to walk-around inspections.

In the PUP, the one original boiler still operating is located in the main building, and the three rental boilers are located in another building on the south side of the main building. Similarly, the four original chillers still operating are in the main building, and the seven rental chillers are in an adjacent building. The major electrical switchgear for the PUP is located in two buildings across the road from the main building. The PUP control room is located on the operating floor of the boiler room and contains only a master steam pressure control and controls for the fixed boiler. The use of fixed and rental boilers and chillers spread between two buildings in the PUP complex, combined with the lack of a centralized control center from which the equipment can be monitored, means that operating personnel must walk considerable distances, both inside and outdoors, to take readings and to check, start, and stop equipment. The physical arrangement of the PUP not only may require more personnel in normal operating conditions, but may hinder personnel from taking corrective steps quickly during an emergency.

In contrast, the arrangement of the NHRP is such that operating personnel should be able to move quickly among the chillers, boilers, and electrical equipment rooms. All major equipment is located under one roof, with the chillers on the north, the boilers on the south, and the electrical switchgear in the middle. The control room is located on the second floor above one of the electrical load centers and overlooks both the chiller room and the boiler room. Windows located in the control room and in the second floor passageway of the NHRP allow visual observation of much of the critical equipment. In addition, the control

console work station and annunciators in the control room enable centralized monitoring so that corrective steps can be initiated rapidly in an emergency.

MECHANICAL SYSTEMS

Table 3-1 lists the major equipment in the principal mechanical systems in the PUP and NHRP. The systems include steam generation, feedwater and water treatment, fuel storage and supply, steam distribution and condensate return, refrigeration, auxiliary, and sewage systems.

Steam Generation Systems

The PUP has one permanent boiler, which is rated at 125,000 pounds per hour and has an operating pressure of 125 psig, and three rental boilers rated at 60,000 pounds per hour and 125 psig. The combination of fixed and rental boilers with different designs and controls makes PUP operations complex. (The combination has relatively no effect on maintenance, however, because the owner of the rental units is responsible for major maintenance.) The NHRP will have six boilers rated at 40,000 pounds per hour and 125 psig. Because the design and controls of the new boilers are identical, operation of the NHRP should be easier. With age, the boilers in the NHRP will require increased maintenance, but since the primary fuel is natural gas, degradation should be gradual.

The soot blowers in the PUP are operated with compressed air; those in the NHRP are operated with steam. Although the steam soot blowers are more effective, they are generally more maintenance intensive. However, since natural gas will be burned most of the time, the demands for soot blowing will be modest, so the impact of the steam soot blowers on maintenance burden should not be significant.

Feedwater and Water Treatment Systems

The principal differences between the PUP and NHRP feedwater and water treatment systems are the number and type of feedwater pumps and the operation of the water softening and chemical treatment systems. The PUP has three turbine-driven feedwater pumps, and the NHRP has six motor-driven pumps. Four of the NHRP pumps are rated at 102 gallons per minute (gpm), and two, at 204 gpm. Each has a total developed head of 443 feet. Although the turbine-driven pumps are more efficient, they are more complicated to start and operate; the major advantage of the motor-driven pumps is that they are more amenable to automation. From a maintenance standpoint, even though there are twice as many feedwater pumps in the NHRP, the motor drives are less of a maintenance burden than the turbine drives.

The water softening and chemical treatment systems in the NHRP are automated. Those in the PUP are operated manually, and operators spend about one hour per shift testing the water and adding chemicals. Although automatic operation of those systems is certainly desirable, experience has shown that automatic water softening and chemical treatment systems often are not well engineered and can be unreliable. Consequently, they require significant maintenance attention. Experience at other utilities plants with automated water softening and chemical treatment systems indicates that those systems seldom receive the maintenance they need because they are not a vital link for system operation. In contrast, maintenance of manual systems is a routine part of plant operations. Unless the NHRP systems are carefully designed and maintained, the burden on the NHRP staff likely will not be much different from current practices and the associated burden on the PUP staff.

Fuel Storage and Supply Systems

The NHRP will have two 300,000-gallon fuel oil tanks, which is about the same as the capacity of the two original PUP tanks. Coupled with the fact that natural gas will be fired most of the year, the effort required for fuel offloading should not be a major burden on the NHRP staff.[1]

Operation of the fuel systems (natural gas and No. 2 oil) in the NHRP should parallel the PUP. In addition, although there are six fuel oil pumps for the boilers in the NHRP versus three in the PUP, these components traditionally require little maintenance.

Steam Distribution and Condensate Return Systems

The steam distribution and condensate return systems in the PUP consist principally of the 16-inch steam distribution piping and the 8-inch high pressure and 3-inch low pressure condensate return piping. The NHRP will use most of the same piping and components. However, to reduce the heavy maintenance requirements of the steam distribution systems, several modifications are planned:

- Replacement of steam piping expansion joints with the nonleaking bellows type. This activity has been started.

- Installation of a new ring header in the inner court of the Pentagon to enable isolation of sections of the Pentagon. The ring header will be installed in

[1]Major effort was required during January through March 1994 because only 60,000 gallons could be stored in the temporary tanks that replaced the two 262,000 gallon tanks. Because of high residential demand, natural gas was cut off from the PUP. Oil consumption during the cold spells was about 22,000 gallons per day, and emergency shipments by tanker truck (7,000 gallons per truck) were necessary. Additional storage capacity will be needed for winter operation of the PUP until the NHRP tanks are installed.

phases, so the existing outer header will remain in operation for an extended period of time (probably 10 years).

In addition to the existing distribution system, the NHRP will have a second steam distribution and condensate return system and a new pipe tunnel from the heating plant to the FOB 2 piping vault. This redundant system, although doubling the number of valves, traps, etc., will enable staff to perform preventive maintenance on a planned basis, which should reduce the burdens associated with unscheduled maintenance demands and improve the reliability of the system.

Refrigeration Systems

The major differences between the PUP and NHRP refrigeration systems are the numbers and ratings of refrigeration chillers, including the condensers, compressors, motors, pumps, and other associated equipment. The PUP currently has four 5,000-ton original chillers and seven 1,000-ton rental units; the NHRP will have ten 3,750-ton units. Although the numbers of major components are similar, the identical design and control of the NHRP chillers should simplify operations and maintenance.

The NHRP will use the same chilled water distribution system (supply and return) being used by the PUP plus a new, second system to reduce the priority (unscheduled) maintenance and enable scheduling of preventive maintenance. Like the redundant steam distribution and condensate return lines, the redundant chilled water supply and return lines will simplify maintenance and improve system reliability.

Two chilled water distribution booster pumps, a sump pump, and local control panel will be installed in the FOB 2 vault, located on the west side of the Pentagon. Those will require periodic checks. Monitoring data feedback to the NHRP control station should be provided to reduce the frequency of off-site checks.

Auxiliary Systems

The auxiliary system in which the differences between the PUP and the NHRP are significant is the compressed air system. The PUP has a variety of types of air compressors: one single-stage reciprocating, three two-stage, and two rotary screw. The NHRP will have two instrument air compressors and three service air compressors. All five compressors will be of the reciprocating, single-stage, double-acting type, presumably from the same manufacturer. Accordingly, operation and maintenance should be less of a burden than is the case for the PUP compressed air system.

Other auxiliary systems of significance include plant services: vacuum, elevator, telephone, intercom, cranes, fire protection, and heating, ventilation, and

air conditioning. Changes in these systems for the NHRP should have little impact on staffing.

Sewage System

The NHRP will use the existing sewage pumping station. A second sewage system is to be added for redundancy, but details on the equipment have not yet been obtained. The current system requires significant attention by PUP personnel; it must be checked every shift, pumps must be unclogged, the comminutor must be overhauled, etc. Since the sewage pumping station is located off-site, the checks require vehicle travel. A backup system for the NHRP should reduce the need for surveillance and priority maintenance. Furthermore, remote monitoring of the pumps should be added to the NHRP data system to reduce the frequency of the checks.

ELECTRICAL SYSTEMS

Table 3-2 lists the major electrical equipment in the PUP and NHRP. Compared to the PUP, the NHRP has more electrical equipment, primarily because it has a larger number of major components, for example, boilers and chillers. The following is a comparison of the PUP and NHRP electrical equipment requirements:

	PUP	NHRP
13.8/13.2-kV circuit breakers	28	22
4.16-kV circuit breakers	0	41
2300-V circuit breakers/fused switches	44	0
480-V circuit breakers	35	222
277/208-V circuit breakers/fused switches	82	0

Preventive maintenance and major repairs for electrical equipment are contracted by PUP and likely will be by NHRP. Therefore, the major difference between the two plants will be in the area of contract costs, particularly after 5 to 10 years as the equipment ages. From an operating standpoint, automation should simplify the start-up and shutdown of equipment in the NHRP. However, since not a lot of effort is required to operate the PUP electrical systems, the impact on staffing will be minimal.

Unlike the PUP, the NHRP will have five 3,600-kW emergency diesel generators, but details on the emergency system have not been made available. The addition of emergency generators could increase the maintenance burden unless

the maintenance is contracted. Personnel assigned to operate and perform corrective (minor) maintenance on the diesel generators will require special training and upgraded qualifications.

System Controls

The PUP uses mostly local on/off analog controls, but some equipment – the rental chillers and boilers and the 5,000-ton original chillers, for example – has local digital controls. The principal features of the NHRP control system are as follows:

- Modulating and digital control, monitoring, data acquisition, alarm, and indication systems.
- Master controller, which includes controls for boiler combustion, intake air, flue gas and flame safety, boiler auxiliaries, chiller condenser water system, chiller diagnostics, chilled water, and electrical distribution.
- Eight workstations, including
  - three each for chillers and boilers, containing an operator interface, graphics, and alarms;
  - one for software and system maintenance; and
  - one for the plant manager.
- Communications and control digital equipment and software.

Of the differences between the PUP and NHRP, the use of distributed process controls in the NHRP will have the greatest impact, by far, on the qualification requirements of the NHRP staff. However, additional details on the NHRP control system were not available when this report was prepared.

Table 3-1
Pentagon New Heating and Refrigeration Plant
Major System and Equipment Listing
Including Comparative Data in Existing Pentagon Utilities Plant
Mechanical Systems

System	New Heating And Refrigeration Plant					Existing Utilities Plant		
	Equipment				Physical Features	Equipment		
	Type	Size	No.	Location		Type	Size	No.
Steam Generation	Boiler - Design Press - Operating Press - Operating Steam Temp - Factory Assembled, Stud Mounted, Integral Burner and Fans, Economizer and Fuel Oil Heater - 3% Continuous Blowdown - Primary Fuel - Nat. Gas - Alternate Fuel - No.2 Oil - Provisional Fuel-No. 6 Oil - Forced Flue Gas Recirculation - Gas - Electric Ignition - Flame Safeguard System - Distributed Process Controller	40k lb/hr 175 PSIG 125 PSIG 353 F < 0.2 %S	6	Heat Plant First Floor	- All boilers located on 1st floor of heating plant. Heating plant master panel located in front of boiler no.1. Each boiler provided with local digital controller with safety interlocks for startup & shutdown. - Multiple choices of fuel supply increases operational complexity. - Emissions monitors when firing fuel oils may necessitate adjustment and tuning of air/fuel feed rates. - Electric feed for FD & Recirc. gas fans from 480V MCC-A4 (location not determined) - Soot blowers operated from local control panel. - Continuous blowdown controlled by individual control valves for each boiler. Blowdown set for 3% of feedwater flow.	Boiler (1 original) - Design Press - Operating Press - Burner and Fans - Fuel Oil Burner Heaters - Continuous Blowdown - Primary Fuel - Nat. Gas - Alternate Fuel - No.2 Oil - Provisional Fuel-No. 6 Oil	125K lb/hr 250 PSIG 125 PSIG < 0.2 %S	1 3
	- Soot Blowing System * Steam with Electric Motor Drive		2			Forced Draft Fan - Soot Blowing System * Compressed Air Receivers * Soot Blower Controller * Soot Blower	29K SCFM	1 2 1 2
	Sample Cooler		8	Heating Plant First Floor (Sampling Sink)		Rental Boilers Blowdown Sampler	60K lb/hr	3 1
	Blowoff Tank		1	Heat Plant Tunnel/Bsmt.				
						Conductivity Controller		1
Boiler Feedwater and Water Treatment	Deaerator	50k lb/hr	1	Heat Plant First Floor	- Feedwater system divided into two deaerator - feedwater pump paths, the large 240K lb/hr deaerator feeding four pumps and the smaller 50K lb/hr deaerator feeding two pumps. - Condensate make up passes through water softener station, then to one of the chemical feed treatment stations (sulfite, amine, and phosphate). The water softening process includes ion exchange resins which are backwashed by brine pump discharge. Chemical additions are by manual batch process. Individual chemical feed pumps are provided for each of the six boilers. Feedwater chemistry control may be man power intensive unless effort is maintained to ensure proper functioning of the controls. - Feedwater flow is measured at the main line leading to all boilers and at the individual boilers. Feedwater flow control at each boiler is provided by a Copes Vulcan electro pneumatic valve. - The water treatment system provides coolant to the shell side of the blowdown heat exchanger. Flow isolation to the heat exchanger is provided by local manual valves. Temperature indication of the inlet and outlet coolant is also local.	Deaerator		2
	Deaerator	240k lb/hr	1	Heat Plant First Floor				
	Boiler Feedwater Pump (Motor Drive)		6			Boiler Feedwater Pump (Turbine Drive)		3
	Blowdown Heat Exchanger		1	Heat Plant First Floor		Blowdown Heat Exchanger		1
	Water Softening Station		1	Heat Plant First Floor		Zeolite Softening System - Regeneration System - Brine System - Effluent Sample Systems		
	Phosphate Chemical Feeder - Chemical Tank - Agitator - Chemical Feed Pump		 1 1 6	Heat Plant First Floor (Chemical Feed Station)		Sodium Sulfite System (Not In Use)		
	Amine Chemical Feeder - Chemical Tank - Agitator - Chemical Feed Pump		 1 1 1	Heat Plant First Floor (Chemical Feed Station)				
	Sulfite Chemical Feeder - Chemical Tank - Agitator - Chemical Feed Pump		 1 1 2	Heat Plant First Floor (Chemical Feed Station)				
						Blowdown Seperator		1
						Boiler Chemical System		1
						Surge Tank		1
Steam Distribution and Condensate	Cond. Receiver		1	Heat Plant Tunnel/Bsmt.	- Steam system includes individual flow transmitters for each boiler as well as a flow transmitter in the main supply line to the Pentagon. Digital controller controls steam drum water level and firing rate based on steam and feed flows and drum level. - Condensate lift pumps controlled by a level transmitter in condensate receiver, and discharge to the condensate storage tank.	Duplex Cond. Receiver		1
	Cond. Lift Pumps		2			Duplex Cond. Rec. Pumps	37 GPM	2
	Cond. Storage Tank		1	Heat Plant First Floor		Cond. Storage Tank		1
	Cond. Transfer Pumps		4			Cond. Pumps (Motor)	10 HP	2
	Cond. Polishing Station		1	Heat Plant First Floor		Cond. Polishers	502 GPM	3
	Condensate HP Drain Piping	8" x 1500'	1			Condensate HP Drain Piping	8" x 3700'	1

Table 3-1
Pentagon New Heating and Refrigeration Plant
Major System and Equipment Listing
Including Comparative Data In Existing Pentagon Utilities Plant
Mechanical Systems

System	New Heating And Refrigeration Plant				Physical Features	Existing Utilities Plant		
	Equipment					Equipment		
	Type	Size	No.	Location		Type	Size	No.
	(1 future from FOB-2)	8"	1		Condensate pumps controlled by level transmitters in condensate storage tank and also in the deaerating tank. - Steam distribution piping includes steam traps and drip legs.			
	Condensate LP Return	3" x 1500'	1			Condensate LP Return	3" x 3700'	1
	(1 future from FOB-2)	3"	1					
	Brine Silo		1	Heat Plant First Floor		Brine Tanks		2
	Brine Pump		2	Heat Plant First Floor		Brine Pump		1
	Pressure Powered Condensate Pump		1					
	Steam Distribution Piping	16" x 1500'	2			Steam Distribution Piping	16" x 3700'	2
Fuel Storage Supply and Natural Gas	Fuel Oil Tank	300k Gal.	2	Fuel Oil Building	- Fuel oil is provided at a fill connection serviced by tanker trucks. Fuel oil transfer pumps discharge to the two storage tanks. Storage tanks equipped with steam heating coils fed from HP steam system. - Fuel oil to boilers provided by fuel oil supply pumps which discharge to a common header. Fuel oil flow to each boiler is measured by individual flow instruments. Header pressure is controlled by one return control valve. (Note: this results in the same fuel oil pressure at each boiler's burners; each boiler contains one combination oil-gas burner.) - Natural gas is provided by Washington Gas Co. at a pressure reduction/flow measurement station next to the plant. The station is owned and maintained by Washington Gas. Gas flow is also measured in the main header by a flow instrument owned by the plant and at individual boilers as well.	Fuel Oil Tanks		3
	Fuel Oil Transfer Pump		2	Fuel Oil Building		Fuel Oil Unloading Pumps		3
	Fuel Oil Supply Pump		6	Fuel Oil Building		Fuel Oil Burner Pumps		3
	Fuel Oil Tank Suction Heater		2			Truck Unloading Station		
Refrigeration Chilled Water	Chiller - Condenser - Compressor - Motor - Gear Drive - Cooler - Intercooler	3750T 3000 HP	10	Refr. Plant 1st Floor	- 10 Chiller units, starters, and Refr. plant master panel located on Refr. plant 1st floor. Microprocessor monitor/alarms include R22 inlet temp, compressor vibration sensors, lube oil press. and temp, R22 inlet and outlet temp and press; motor temp., volts, amp, power, and power factor. - Individual chiller starters located adjacent to chillers - Refrigerant plant master panel positioned between Chiller nos. 1 & 3. - Chiller motor electrical feed from 4160V Dist. Swgr. panel loc. on Refr. plant 1st floor, accessible through doors from Refr. machinery space.	Chiller(York) - Condenser - Compressor - Motor - Gear Drive - Cooler - Intercooler - Evaporator - Leak Detection System - Air Purge Unit	5000T 12K GPM 5000T 6000 HP 5000 T	4
						Rental Chillers	1000T	7
	Chiller Loop Pump		10	Refr. Plant Bsmt. Floor	- Chiller loop pumps circulate water through Chillers, to inlet of Chilled water dist. pump	Thermo Cycle Pumps		2
	Chilled Water Chemical Feed Pump - Feed Drum - Injector		2	Refr. Plant Bsmt. Floor	- Chilled water dist. pumps circulate water to Pentagon and FOB. - Chiller loop pumps and dist. pumps loc. in Bsmt. of Refr. Plant - Two chilled water distribution booster pumps located in FOB-2 vault, on west side of Pentagon, will require periodic monitoring. FOB-2 vault contains sump pump and local control panel. - Electrical feeds for chiller loop and for chiller dist. pumps - from 480V load center B; both pumps from 480V MCC-A1 located on 1st floor. - Chilled water chemical feed pumps and drum located in basement; require periodic additions of chemicals and pump operation. - Centrifugal seperator in Refr. Bsmt. operated periodically for R22 cleanup. - Chiller Testing Heat Exchanger located in basement of heating plant; used infrequently. - Chilled water distribution supply and return piping, ea. approx. 1500 ft., to Pentagon and FOB, located in tunnel; requires periodic surveillance. - Condenser water supply system components located in same area as chiller system - Bsmt. and 1st floor of Refr. plant - traveling screens & backwash strainers will require			
	Chilled Water Pump		4	Refr. Plant Bsmt. Floor		Chilled Water Pump	7600 GPM 7600 GPM 13K GPM	1 4 1
	Chiller Testing Heat Exchanger		1	Heat Plant Tunnel/Bsmt. (Temporary)				
	Centrifugal Seperator		1	Refr. Plant Bsmt. Floor		Centrifugal Seperator		1
	Expansion Tank		4	Refr. Plant Bsmt. Floor		Chilled Water Balance Tank		1
Chilled Water Distribution	Chilled Water Distribution Booster Pump		2	FOB-2 Pump Vault				
	Distribution Piping Supply and Return	36" OD x 1500		Tunnel to Pentagon and FOB		Distribution Piping Supply and Return	36" OD x 3700'	
Condenser Water Supply	Screen Wash Pump		3	Refr. Plant Bsmt. Floor		Traveling Screen (Motor)	3HP	1
	Traveling Screen - Spray Header		2	Refr. Plant 1st Floor				
	Sump Dewatering Pump		2	Refr. Plant 1st Floor		Condenser Water Pit Pump out Pump	1000 GPM	1
	Condenser Water		10	Refr. Plant 1st Floor		Condenser Water Pump	11K GPM	5

Table 3-1
Pentagon New Heating and Refrigeration Plant
Major System and Equipment Listing
Including Comparative Data in Existing Pentagon Utilities Plant
Mechanical Systems

System	New Heating And Refrigeration Plant				Physical Features	Existing Utilities Plant		
	Equipment					Equipment		
	Type	Size	No.	Location		Type	Size	No.
	Pump				periodic attention.		15750 GPM	1
	Automatic Backwash Strainer		10	Refr. Plant 1st Floor	- Electrical feeds to condenser water pumps from 4.16KV MCC-CP1 located on 1st floor of Refr. plant, near pumps. Feed for traveling screens located at MCC-A2 at opposite corner of 1st floor of Refr. plant.	Condenser Water Strainers (North and South)	36K GPM	2
						Cond. Water bar screen (Motor)	3 HP	1
						Condenser Water Sluice Valves - Man Operated		2
Refrigerant Vent and Pumpout	Refrigerant Pump Out Unit - Condenser/Compressor Package - Receiver		3	Refr. Plant Bsmt. Floor		Refrigerant Pump Out Unit - Condenser/Compressor Package (Motor) - Receiver tank	7.5 HP 181.5 ft^3	1
						Chilled Water Make Up - Tank - Float Controlled Pump - Chilled Water Centrifugal Seperator	350 Gal. 100 GPM	1 2 1
Compressed Air	Inst. Air Compressor Pkg. - Compressor - Intake Silencer Filter - Aftercooler - Moisture Seperator	50 SCFM	2	Refr. Plant Bsmt. Floor	- All equipment located in bsmt of Refr. plant. No remote monitoring indicators - all instruments are local. Low pressure switch provided. - Electrical feed to air compressors from 480V MCC-A2 located at the opposite end of Refr. plant 1st floor.	Air Compressors - Single Stage Reciprocating (Motor) - Two Stage Reciprocating - Rotary Screw	10 HP 142 SCFM 25 SCFM 175 SCFM	8 1 2 1 2
	Svc. Air Compressor Pkg. - Compressor - Intake Silencer Filter - Aftercooler - Moisture Seperator	120 SCFM	3	Refr. Plant Bsmt. Floor		After Coolers Moisture Seperators Compressed Air Filter		4 4 1
	Refrigerant Air Dryer		3	Refr. Plant Bsmt. Floor		Refrigerated Air Dryer	100 SCFM	1
	Dual Tower Dessicant Air Dryer		1	Refr. Plant Bsmt. Floor		Dessicant (Roberts) Air Dryer (Hankinson)	100 SCFM 110 SCFM	1 1
	Air Receiver	200 Gal.	2	Refr. Plant Bsmt. Floor		Plant(Wet) Air Receiver		5
	Air Receiver	120 Gal.	2	Refr. Plant Bsmt. Floor		Control(Dry) Air Receiver		1

Table 3-2
Pentagon New Heating And Refrigeration Plant
Major System And Equipment Listing
Including Comparative Data In Existing Pentagon Utilities Plant
Electrical System

New Heating And Refrigeration Plant				Existing Utilities Plant			
	Equipment				Equipment		
System	Type	Size	No.	System	Type	Size	No.
13.8 KV Distribution Switchgear	VEPCo XFMR - Main Feed	25/33 MVA 69 -13.8KV	3	13.2KV Switchgear Switch House No. 1	VEPCo Line - Main Feed	13.2 KV	3
	Circuit Breaker - Main Line to 13.8 KV Bus	13.8 KV 2000A	3		Circuit Breaker - Main Line to 13.2 KV Bus (GE Type M-38)	13.2 KV 1200 A	3
	Circuit Breaker - Tie Between Busses	13.8 KV 3000A	2		Circuit Breaker - Tie Between Buses.	13.2 KV 1200 A	2
	Circuit Breaker Sub Feeds To:	13.8KV 1200A	17		Circuit Breaker Sub Feeds to:	13.2 KV 1200 A	12
	- Sewage Treatment Plant Via XFMR (13.8KV - 2300V)	750KVA	- 1		- Pentagon Feeders No.3,4,17,18		- 4
	- Existing Pentagon Feeders 3, 4, 17, 18.		- 4		- To 208/120 V Switchgear Via 500 KVA 13200-208/120V XFMR		- 2
	- 4.16KV Dist SWGR Via XFMR (13.6KV - 4160/2400V)	12/16/20MVA	- 3		- Spare		- 3
	- Incinerator Building XFMR		- 1		- Switch House No. 2 Feeders		- 2
	- Spare		- 3		- To No.15 13.2 KV 2500V XFMR		- 1
	- Spare (Future Power Plant MCC XFMR)		- 2				
	- Spare (Future Power Plant Tie)		- 3				
	- Equipped Space (Not Included In Total)		- 2				
				Switch House No. 2	Circuit Breaker - From Switch House No. 1	13.2 KV - 1200A	2
					Circuit Breaker - Tie Between Buses	13.2 KV - 1200 A	1
					Circuit Breaker - Sub Feeds to:	13.2 KV - 1200 A	10
					- Chillers A-D (Motor)	2750 HP	- 4
					- Chillers E-H Via 4000/5000 KVA XFMR 13.2 KV-4160/2400V (Motor)	5000 HP	- 4
					- To No. 8A, 8B 13.2 KV - 2500V XFMR		- 2
4.16KV Distribution Switchgear	Main Power XFMR from 13.8KV Bus	12/16/20 MVA 13.8 - 4.16/2.4KV	3	2300V Switchgear	13.2 KV Feeds		3
	Circuit Breaker - Main Power XFMR to 4.16KV Bus	4160V 3000A	3		- From Switch House No.2		- 2
	Circuit Breaker - Tie Between Buses	4160V 3000A	4		- From Switch House No. 1 Via 5000 KVA 13.2 KV-2500V XFMR		- 1
	Circuit Breaker Sub Feeds To:	4160V 1200A	19		Circuit Breaker - Feed From XFMR	2500V - 1200 A	3
	- 4.16KV MCC - CP1		- 2		Circuit Breaker - Tie Between Buses	2300V -1200A	2
	- 480V Load Center XFMR (4.16KV - 480Y/277V)	2500/3333KVA	- 4		Circuit Breaker - sub feeds to:	2300V -1200A	9
	- Chiller (Two for Future)		- 12		- Sewage Plant Feeder (Nos. 1,2)		- 2
	* Chiller Starter				- To Precipitator Substation Via 2300Y/430V XFMR (Eliminated)		- 1
	* 4000V Compressor Motor				- Motor Control Center (MCC) 1-4		- 4
	* Control Panel				- 500 KVA XFMR Feeders Nos.1,2		- 2
	- Spare		-1				
4.16KV Motor Control Center (MCC) - CP1	Feed From Breaker on 4.16KV Dist SWGR Bus	4160V 1200A	2	Motor Control Center No. 1	Circuit Breaker - Feed From 2300V Dist. Switchgear	2300V 1200A	1
	Fused Disconnect switch - Tie Between Buses	4160V 450A	1		Fused Switches to:	2500V - 400A	6
	Condenser Water Pump Sub Feed Via:		12		- Machine Shop XFMR		- 1
	- Fused Disconnect Sw. to	100A			- 300KVA XFMR		- 1
	- Contact (Normally Open) to	400A			- No.1 FD Fan		- 1
	- Condenser Water Pump (2 Future)	400HP			- Spare		- 3

Table 3-2
Pentagon New Heating And Refrigeration Plant
Major System And Equipment Listing
Including Comparative Data In Existing Pentagon Utilities Plant
Electrical System

New Heating And Refrigeration Plant				Existing Utilities Plant			
	Equipment				Equipment		
System	Type	Size	No.	System	Type	Size	No.
480V Load Center A	XFMR From 4.16KV Dist. SWGR	4.16KV-480Y/277V	2	Motor Control Center No. 2	Circuit Breaker - Feed From 2300V Dist. Switchgear	2300V 1200A	1
	Main Circuit Breaker - XFMR to 480V Bus	4000AF 4000CS 4000AT	2		Fused Switches to:	2500V - 400A	6
	Circuit Breaker - Tie Between Buses	3200AF 3200CS 3200AT	1		- 300KVA XFMR(1 to Incinerator)		- 2
	Circuit Breaker Sub Feeds To: Motor Control Centers (MCC) A2, A3, A4 (2 each)	1600AF 1200CS 1200AT	6		- Feedwater Pump (Motor)	150 HP	- 1
	Circuit Breaker Sub Feed To: MCC - A1	2000AF 2000CS 2000AT	2		- Spare		- 3
	Circuit Breaker Spares	1600AF 1200CS	2				
480V Load Center B	XFMR From 4.16KV Dist. SWGR	4.16KV-480Y/277V	2	Motor Control Center No. 3	Circuit Breaker - Feed From 2300V Dist. Switchgear	2300V 1200A	1
	Main Circuit Breaker - XFMR to 480V Bus	4000AF 4000CS 4000AT	2		Fused Switches to:	2500V - 400A	6
	Circuit Breaker - Tie Between Buses	3200AF 3200CS 3200AT	1		- Chilled Water Pump Nos. 3-6		- 4
	Circuit Breaker To:	1600AF 1600CS 1280AT	5		- Condensate Water Pump Nos. 1,5		- 2
	- Chilled Water Distribution Pump (1 Future)	700HP					
	Spare Circuit Breaker	1600AF 1600CS	1				
480V MCC -A1	Feed From 480V Load Center A	480V 2000A	2	Motor Control Center No. 4	Circuit Breaker - Feed From 2300V Dist. Switchgear	2300V 1200A	1
	Main Breaker - From Feed	480V 2000A	2		Fused Switches to:	2500V - 400A	8
	Circuit Breaker - Tie Between Buses	480V 2000A	1		- Condensor Water Pump Nos. 2,3,4,7		- 4
	Chiller Loop Pump Feed Containing:		12		- Chilled Water Pump Nos. 1,2		- 2
	- Circuit Breaker Motor Starter				- Spare		- 2
	- Thermal Switching Device						
	- Chiller Loop Pump (2 Future)	150HP					
480V MCC - A2	Feed From 480V Load Center A	480V 1200A	2	208/120V Switchboard Refrigeration Plant	Feed from 2300V Switchgear Breaker to 2300-208/120V XFMR (500KVA)	500KVA 2300-208/120V	2
	Main Breaker - From Feed	480V 1200A	2		300A Fused Disconnect Switch - Motor Control Centers (E,F,G,H)	300A	4
	Circuit Breaker - Tie Between Buses	480V 1200A	1		225A Fused Disconnect Switch - New Panel "P"	225A	1
	20A Circuit Breaker To:	20 A	25		200A Fused Disconnect Switch - SK Station No. 2 Panel LI	200A	1
	- Motor Operated Valve(2 future)	1.5KW	- 17		175A Fused Disconnect Switch - No. 5 Air Compressor (Motor)	175A 40 HP	1
	- Refr Pump Out Unit	10.5KW	- 3		125A Fused Disconnect Switch - No. 4 Air Compressor (Motor)	125A 30 HP	1
	- Air Dryer	2KW	- 2		100A Fused Disconnect Switch	100A	7
	- Overhead Door	1KW	- 2		- Panel A & B		- 2
	- Traveling Screen	5.5KW	- 1		- Powerroom AC Supply		- 1
	30A Circuit Breaker To Control Panel for AC-4 & AC-5	30A 2 @ 20HP	1		- Outside Lights		- 1
	40A Circuit Breaker To:	40A	13				

Table 3-2
Pentagon New Heating And Refrigeration Plant
Major System And Equipment Listing
Including Comparative Data In Existing Pentagon Utilities Plant
Electrical System

New Heating And Refrigeration Plant				Existing Utilities Plant			
	Equipment				Equipment		
System	Type	Size	No.	System	Type	Size	No.
	- Chiller Aux & Control Panel (2 future)	20KW	- 12		- New Office		- 1
	- Traveling Screen	5.5KW	- 1		- Spare		- 2
	45A Circuit Breaker To Power Panel Via XFMR (480V-208Y/120)	45A 30KVA	1		70A Fused Disconnect Switch - MGA Unit - Chilled Water Make-Up Pump No.2 (Motor) - Guard Building West Hall	70A 15 HP 15 HP	3
	60A Circuit Breaker To - Welding Recepticles - Sump Pump Control Panel * Sump Pumps	60A 2 @ 15HP	3 - 2 - 1		50A Fused Disconnect Switch - Pump Down Refrig. Transfer Pump (Motor) - No. 6, 7 Dry Air Compressor (Motor) - Purge Shop - Exhaust Fan No.6 (Motor)	50A 10 HP 10 HP 10 HP	5 - 1 - 2 - 1 - 1
	90A Circuit Breaker To: - 30 Ton Bridge Crane - Elevator	90A 50KW 50KW	2		40A Fused Disconnect Switch - South Strainer - Crane No.1,2 (Motor) - Condenser Water Pump Oil Relays	40A 7.5 HP	4 - 1 - 2 - 1
	100A Circuit Breaker to Air Compressor Control Panel - Air Compressors (AC-1,2,3)	100A 3 @ 40HP	1		30A Fused Disconnect Switch - Unit Heater 2 @ 1 HP - Chilled Water Make-up Pump No. 1 (Motor)	30A 15 HP	2
	125A Circuit Breaker to: - Power Panels (PP1 & PP1A) Via XFMR (480V-208Y/120V) - Lighting Panel Via XFMR (480V - 480Y/277V)	125A 75KVA 75KVA	2		25A Fused Disconnect Switch - Unmarked Motor - Purge Unit Comp. No. 1,3,5,2,4,6,8,10 (Motor) - North Strainer (Motor)	25A 5HP .5 HP Ea. 5 HP	5 - 1 - 3 - 1
	225A Circuit Breaker To: - Power Panel B (PPB) - Another 225A Circuit Breaker to PPA Both Via XFMR (408V-208Y/120V)	225A 150KVA	1		20A Fused Disconnect Switch for 5000 KVA XFMR Nos. T-7,13 and T-8,15	20A 4.25 HP Ea.	2
	Unmarked Circuit Breakers - Backwash Strainer (2 Future) - Screen Wash Pump - Basement Exhaust Fan - Basement Vent Fan - Pressure Maintenance Pump - Sump Dewatering Pump - Spare	 .75HP 20HP 1HP, 5HP 7.5HP, 15HP, 20HP 7.5HP 25HP	26 - 12 - 3 - 2 - 3 - 1 - 2 - 3		17.5A Fused Disconnect Switch for Screen Motor	17.5A 3 HP	1
					15A Fused Disconnect Switch - Air Dryer - Door Motor	15A	2
					8A Fused Disconnect Switch for Electric Shop Fan (Motor)	8A 1 HP	1
480V MCC -A3	Feed From 480V Load Center A	480V 1200A	2	208/120V Switchboard Heating Plant	Circuit Breaker - Feed from 13.2 KV Switchgear Switch House 1 Via 5000 KVA XFMR 13200-208/120V	600A	2
	Main Breaker - From Feed	480V 1200A	2		Tie Between Breaker	50A	1
	Circuit Breaker - Tie Between Buses	480V 1200A	1		Circuit Breaker Sub Feeds to: - Power Panels 1,3,2,4, Unmarked - 13.2KV Heaters - 13.8 KV Swtch Station A Panels - Freight Elevator - Spare	50A	9 - 5 - 1 - 1 - 1 - 1
	20A Circuit Breaker To: - Return Fan - Air Handling Unit	20A 7.5HP 10HP	2				
	30A Circuit Breaker To Station Battery Charger	30A 15KW	2				
	70A Circuit Breaker To Lighting Panel Via XFMR (480V-480Y/277V)	70A 112.5KVA	1				
	175A Circuit Breaker To PP3 & PP3A Via XFMR (480V-208Y/120)	175A	1				
	Unmarked Circuit Breakers - Vent Fan - Exhaust Fan - Basement Vent Fan - Air Handling Unit(AHU) - Return Fan - Make UP Air Unit	 3HP, 7.5HP 5HP 10HP 5, 10, 15, & 15HP 3HP 20HP	25 - 14 - 1 - 1 - 4 - 1 - 1				

Table 3-2
Pentagon New Heating And Refrigeration Plant
Major System And Equipment Listing
Including Comparative Data In Existing Pentagon Utilities Plant
Electrical System

New Heating And Refrigeration Plant				Existing Utilities Plant			
	Equipment				Equipment		
System	Type	Size	No.	System	Type	Size	No.
	Hot Water Circ Pump	7.5HP	- 1				
	Spare		- 2				
480V MCC - A4	Feed From 480V Load Center A	480V 1200A	2	MCC - E	CB From 208/120V Switch Brd.	300A	1
					200A Fused Disconnect Switch to Panel E	200A	1
	Main Breaker - From Feed	480V 1200A	2				
					55A Fused Disconnect Switch to Exhaust Fan (Motor)	55A 15 HP	1
	Circuit Breaker - Tie Between Buses	480V 1200A	1				
					35A Fused Disconnect Switch to Gear Aux Oil Pump (Motor)	35A 7.5 HP	1
	20A Circuit Breaker To:	20A	7				
	- Overhead Door	1KW	- 2		25A Fused Disconnect Switch to Thermocycle Pumps	25A 5 HP	2
	- Condensate Receiver	6.12KW	- 1				
	- Motor Operated Valve	1.5KW	- 2		8A FusedDisconnect Switch to Compressor Aux. Oil Pump	8A	1
	- Dockleveler	1.15KW	- 1				
	- Vacuum Blower	10KW	- 1	MCC - F	CB From 208/120V Switch Brd.	300A	1
	60A Circuit Breaker To:	60A	3		200A Fused Disconnect Switch to Panel F	200A	1
	- Condensate Tank	31.88KW					
	- Welding Receptacle(3)	600V, 60A			55A Fused Disconnect Switch to Exhaust Fan (Motor)	55A 15 HP	1
	- Control Panel for Sewage Pumps	2 Pumps @ 15HP					
	70A Circuit Breaker To:	70A	3		35A Fused Disconnect Switch to Gear Aux Oil Pump (Motor)	35A 7.5 HP	1
	- Motor Control Center	45KVA					
	- Power Panel Via XFMR (480V-480Y/277V)	45KVA			25A Fused Disconnect Switch to Thermocycle Pumps	25A 5 HP	2
	- Power Panel Via XFMR (480V-208Y/120V)	45KVA			8A FusedDisconnect Switch to Compressor Aux. Oil Pump	8A	1
	100A Circuit Breaker To Deaerator	100A 50.99KW	1	MCC - G	CB From 208/120V Switch Brd.	300A	1
					200A Fused Disconnect Switch to Panel G	200A	1
	125A Circuit Breaker To	125A	2				
	- Power Panels PP2A & PP2 Via XFMR(480V-208Y/120V)	75KVA			55A Fused Disconnect Switch to Exhaust Fan (Motor)	55A 15 HP	1
	- Motor Control Center (MCC-A1-1	67.5KVA					
	175A Circuit Breaker To Lighting Panel (LP2) Via XFMR (480V - 480Y/277V)	175A 112.5KVA	1		35A Fused Disconnect Switch to Gear Aux Oil Pump (Motor)	35A 7.5 HP	1
					25A Fused Disconnect Switch to Thermocycle Pumps	25A 5 HP	2
	250A Circuit Breaker To Dearator (DEA-1)	250A 133.85KW	1		8A FusedDisconnect Switch to Compressor Aux. Oil Pump	8A	1
	Unmarked Circuit Breakers		33	MCC - H	CB From 208/120V Switch Brd.	300A	1
	- Boiler FD Fan	30HP	- 6		200A Fused Disconnect Switch to Panel H	200A	1
	- Vent Fan (Stm Plant)	7.5HP	- 8				
	- Exhaust Gas Recirc Fan	15HP	- 6		55A Fused Disconnect Switch to Exhaust Fan (Motor)	55A 15 HP	1
	- Brine Pump	5HP	- 2				
	- Make UP Air Fan	10HP	- 6		35A Fused Disconnect Switch to Gear Aux Oil Pump (Motor)	35A 7.5 HP	1
	- Air Handling Unit(AHU-5)	2HP	- 1				
	- Spare		- 4		25A Fused Disconnect Switch to Thermocycle Pumps	25A 5 HP	2
					8A FusedDisconnect Switch to Compressor Aux. Oil Pump	8A	1
480V MCC (A4-1, A4-2)	Feeders From MCC-A4		2	480/277V 600A Bus MCC - 1	Circuit Breaker - Feed From MCC -1 2300V Via XFMR 2300 - 480/277V	300KVA	2
	- A4-1 Feeder	70A					
	- A4-2 Feeder	125A			100A Circuit Breaker to:	100A	9
	125A Circuit Breakers - Feeder Lines	125A	2		- Chiller Plant AHU Nos. 1-8		- 8
					- Primary Breaker Panel - E		- 1
	20A Circuit Breakers	20A	3		60A Circuit Breaker to No. 1 Unloading Pump	60A	3
	- Site Lighting	1.9KW	- 2				
	- Unit Heater	7.5KW	- 1		30A Circuit Breaker to:	30A	3
	45A Power Panel(PP4) Via XFMR (480V-208Y/120V)	45A 30KVA	1		- Brine Pump		- 1
					- Burner Pump & Heater Set Nos. 1,2.		- 2
	Unmarked Circuit Breakers		13		20A Circuit Breaker to:	20A	4

Table 3-2
Pentagon New Heating And Refrigeration Plant
Major System And Equipment Listing
Including Comparative Data In Existing Pentagon Utilities Plant
Electrical System

New Heating And Refrigeration Plant				Existing Utilities Plant			
	Equipment				Equipment		
System	Type	Size	No.	System	Type	Size	No.
	- Fuel Oil Supply Pump	5HP	- 6		- Foam Fire Pump		- 1
	- Fuel Oil Transfer Pump	20HP	- 2		- Nos. 1,2 Hot Circulating Pump.		- 2
	- Sump Pump	1HP, 1.5HP	- 3		- Vacuum Pump		- 1
	- Spare		- 2		15A Circuit Breaker to	15A	4
					- Burner Pump & Heater Set No. 3		- 1
					- Sludge Pump		- 1
					- Condensate Pump & Receiver Nos. 1,2		- 2
Diesel Generators (Details Not Yet Obtained)	Catepillar	3600 KW	5	DC System Panel No.1	Feed from Panel E	120 VAC	1
					Battery Charger No. 3		1
					Sub Feeds to:	125 VDC	2
					- Test Rack 2300V Switchgear		
					- DC 2300V Switchgear		
				DC System Panel No. 2	Feed from Panel 3	120 VAC	1
					Battery Charger No. 2		1
					Sub Feeds to:	125 VDC	5
					- Main Alarm Console - Comp Room		
					- DC Control Bus A&B		
					- DC Test Equip.		
					- 2 KV Switchroom Accuator		
					- Transfer Switch		
				DC System Panel No. 3	Feed from Panel 2	120 VAC	1
					Battery Charger No. 1		1
					Sub Feeds to:	125 VDC	3
					- Nos.1,3 Trans. Bus DC Control		- 2
					- 13.8 KV Switchgear Controls		- 1
				Diesel Engine Generator System	Diesel Engine Generator	100 KW	1
					- Circuit Breaker	150A	
					Automatic Transfer Switch to	225 A	1
					- "MDP" 225A Bus 480/277V		
					- Unit Substation		
				Unit Substation	Secondary Load Breaker		1
					150 KVA XFMR 2300V - 480/277V		1
					Fuse Compartment		1
					Double Air Interupter Switches	2300V 600A	1
					- FDR #29 From Va.		
					- FDR # 53 From Heating Plant		
				MDP 225A Bus 480/277V	200A Circuit Breaker to Pump Control Board	200A	1
					20A Circuit Breaker to	20A	2
					- Spare		
					- LVP		
					15A Circuit Breaker to:	15A	7
					- Air Comp Rt., Lt.		- 2
					- Upper & Lower Floor Htr.		- 2
					- Battery Charger		- 1
					- Spare		- 2
				Pump Control Board	Feed from "MDP" 225A	200A	1
					Pumps No. 1,3		4
					Raw Sewage & Water Seal Pumps		2

CHAPTER 4

Staffing Plan

This chapter briefly describes the organization and staff assignments of the PUP and proposes an organization and staff assignments for the NHRP. It also recommends transitional staffing needed for phase-in of the new plant. In general, since the NHRP's mission, objectives, and equipment are similar to those of the PUP, the organization of its staff also will be similar. However, fewer staff will be needed; in contrast to the 72 positions at the PUP, 34 personnel can manage, operate, and maintain the NHRP. To provide the flexibility necessary with reduced staffing, NHRP personnel will have to be cross-trained to perform duties outside of traditional roles. For example, electricians will be called upon to repair instruments or to start the diesel generators, and boiler operators may need to operate circuit breakers for the chiller motors. In addition, the NHRP staff will have to be more highly qualified than PUP staff. Some advanced knowledge of process theory and system dynamics is essential to interpret computer displays and to determine when process controls are malfunctioning. Skills for supporting the advanced digital control and communications systems also will be required. Specific position descriptions – including job summaries, position functions, responsibilities, and knowledge/skill requirements – for NHRP staff are provided in Appendix C.

ORGANIZATION

Figure 4-1 shows the PUP organization as of March 1994. The PUP's 72 authorized positions include management and administrative staff, general and assistant general foremen, electrical distribution facilities staff, operations staff, and repair staff. Of the 72 positions, 62 constitute the in-plant work force. Currently, 26 positions (36 percent) are vacant. All but two of the vacancies are in the wage grade category that comprises the in-plant work force, i.e., nearly all vacancies are in the operations and maintenance departments.

Figure 4-2 shows the proposed organization plan for the NHRP. The proposed plan shows 34 positions, 12 fewer than are currently filled at the PUP. Fewer positions are proposed principally in the management and administrative staff and in the utility systems repairer operator (USRO) staff. New positions for the NHRP include a computer systems specialist (which eventually may be a part-time or contract assignment) and additional electronic industrial controls mechanics (EICMs).

To benchmark the staffing proposed for the NHRP, we contacted eight comparable facilities to determine their staffing levels, the types of equipment they operated, and their experiences. We concluded that modern, well-designed

plants with computer controls can be staffed with modest numbers of personnel and that the staffing level proposed for the NHRP is reasonable. Appendix D provides more detail about our facility survey.

STAFF ASSIGNMENTS

Tables 4-1 through 4-5 summarize the position descriptions for PUP and NHRP management and administrative staff, operations staff, general and assistant general foremen, maintenance department staff, and electrical distribution facilities staff. Staff functions are discussed in the following subsections.

Management and Administration

The PUP has 11 management and administrative staff positions. The positions include 5 management personnel, 2 staff support (clerical) personnel, 1 plant operations assistant, 1 management assistant, 1 supply technician, and 1 motor vehicle operator. In contrast, the NHRP has just 5 management and administrative staff positions. The management positions include the plant manager and the operations and maintenance manager. The administrative staff includes a management assistant (data base and reports) and 2 support staff capable of performing both clerical and supply (stores) functions.

The proposed management and administrative staffing for the NHRP is accomplished by eliminating three supervisor mechanical engineer positions, one supply technician, and one motor vehicle operator. Elimination of two of the engineer positions for new construction assumes completion of construction of the NHRP; functions associated with the third engineer position will be provided by exiting Federal Facilities Division (FFD) staff, primarily in the area of contract administration for outside support. Administrative staff reductions assume that routine, periodical reports can be automated, planning for which should occur as the computer software for the plant is developed. (Depending on the rate of automation, it may be necessary to carry additional personnel temporarily.) The elimination of the motor vehicle operator position assumes that the associated tasks can be handled by the FFD motor pool.

Operations

Operation of the PUP is under the direction of the general foreman, who reports to the supervisor, mechanical engineering (operations and maintenance). The operations staff includes 25 positions, of which 7 are vacant. Operating shift assignments are filled by five crews of four persons each; each crew consists of a foreman, two mechanical operators, and a water tender. An electrician is also assigned to each shift. One shift per week is filled by personnel from the repair department. The electrician and a mechanical operator perform an off-site tour of the sewage plant and intake structure at the lagoon each shift; that tour usually

requires an hour, but can take longer if problems are found. Surveillance tours and hourly readings of equipment within the PUP requires one person full-time.

Operation of the NHRP is under the direction of the watch foreman on duty. A shift crew consists of the watch foreman, one USRO, a repair mechanic, and an electrician. Twenty personnel in all are assigned to shift work. The position description for both the watch foreman and the USRO requires that these personnel hold a District of Columbia Class 1 Steam Engineer license or possess equivalent experience. The organization chart for the NHRP, Figure 4-2, shows the repair mechanics and electricians assigned to the operating shifts but administratively reporting to the USRO general foreman who schedules work assignments and exercises technical direction for planned assignments (preventive maintenance) performed during the shift. However, to ensure operational needs of the plant are met, the watch foreman assigns the priority of work during the shift.

The computer systems specialist is a member of the operations staff; this specialist's duties include software modifications, program debugging, and technical direction and training for the operating staff. This position will be required for one or two years after start-up of the NHRP in order to complete the functional and operational transition. Plant experience will determine whether this position can eventually be reduced to part-time or be contracted.

The proposed staffing for operation of the NHRP represents a significant change from current PUP staffing. As noted earlier, the introduction of distributed control systems enables centralized control and monitoring, but requires a higher level of system understanding to assess computer output and utilize computer-based control interfaces. We believe this can be accomplished by having highly skilled, well-trained, multidisciplinary shift personnel.

The level of staffing proposed for shift assignments provides coverage for more shifts per week than needed based on calendar time. With five shifts, each assigned five days per week, extra personnel would be available for four non-shift days per week. In addition, having extra personnel allows for leave, training, sick time, etc. Note that the ratio of required shifts per week, 21, to the number of shifts available, 25, is 0.84. That ratio corresponds closely to current government planning practice, which assumes 1,770 hours per year actual on-the-job time compared with 2,080 hours theoretical time (52 weeks per year times 40 hours per week).

Compared to the operators in the PUP, the NHRP operators will spend more of their time in the control room. Therefore, shift assignments assume personnel are cross-trained so they can function effectively as boiler operators and chiller operators, electricians and instrument technicians, etc. Cross-training represents a departure from the traditional roles staff performed individually as boiler tenders, mechanics, etc. The long-term goal of the NHRP should be to have all shift personnel trained as operators.

Maintenance

The PUP repair department has 22 positions, of which 9, including the position of steamfitter foreman, are vacant. With the current staffing, 4 personnel perform repairs, 3 are assigned to relief shift duties and perform repairs when available, 2 perform cleanup duties, 2 are lead foreman, and 1 is the repair department foreman. Another 14 positions are assigned to PUP electrical distribution facilities. Those positions include a foreman and assistant foreman (both vacant), 2 EICMs (1 vacancy), 6 distribution facilities electricians (2 vacancies) and 4 electricians (2 vacancies).

The proposed maintenance staff for the NHRP comprises the general foreman, four pipefitter-welders, five repair mechanics, five electricians, and three EICMs. The repair mechanics and electricians are assigned to shift duties and will perform operational functions as well as repair and maintenance tasks. The electricians should be qualified to perform routine instrumentation and controls repairs when the EICMs are not available.

The proposed reduction in maintenance personnel stems from the new condition of the equipment and the redundant distribution steam and chiller piping systems, which will reduce the frequency of unscheduled and emergency repair and maintenance, as well as from the efficiency gains resulting from cross-training.

TRANSITIONAL STAFFING

Although the functions of the equipment in the PUP and NHRP are similar, the configuration and controls are significantly different. In addition, start-up and testing of the new equipment will be necessary as installation is completed. Personnel will have to be trained in the operation of the new equipment. Concurrently, existing services to the Pentagon and other buildings will need to be maintained. Dual staffing for some period prior to commissioning of the NHRP will be necessary to provide training and testing and to ensure continuity of service.

The priority for staffing is in operations, followed by maintenance and then administrative personnel. The first position to be filled is that of plant manager, followed by the operations and maintenance manager, watch foremen, computer systems specialist, and shift operators. The plant manager, operations and maintenance manager, and watch foremen should be dedicated to the NHRP rather than working at both the PUP and the NHRP. The operating shift personnel (USROs) for NHRP can be drawn from the PUP staff, depending on their availability. Temporary personnel will have to be brought on board (perhaps on loan from GSA-HOTD) for a few months while the NHRP boilers and chillers are being phased in, but the PUP is still operating.

The staffing schedule follows the construction-erection-testing sequence for equipment and systems. Figure 4-3 shows the schedule of key events for construction completion and the recommended schedule for personnel loading. The construction schedule reflects best estimates based on information obtained in early July 1994. The original schedule called for completion of the NHRP by October 1995; the current schedule shows completion by December 19, 1995.

The key events setting the recommended rate of personnel loading are chiller and boiler installation and testing, training, and testing of control systems. The plant manager and the operations and maintenance manager should be assigned 15 to 18 months before plant completion, sometime in the third quarter of 1994. We recommend an early start date to allow their input to control room layout, arrangement and sequencing of annunciators, and selection of CRT screens. Watch foremen should be phased in from December 1994 to May 1995. Shift personnel (operators and maintenance personnel) should be assigned to coincide with start-up tests and training, i.e., on site by the beginning of September 1995. Other maintenance personnel can be assigned 2 to 3 months and administrative staff about 1 month prior to completion of the plant.

Position descriptions for the plant manager, operations and maintenance manager, computer systems specialist, watch foremen, general foreman, control operators, repair mechanics, electricians, and EICMs are included in Appendix C and reflect the additional responsibilities required for the automated features and digital control system of the NHRP. Position descriptions for other NHRP personnel (pipefitter-welders and administrative staff) are essentially the same as those now in use at the PUP.

Table 4-1.
Comparison of Management and Administrative Staff Positions for PUP and NHRP

Position	Grade	Existing plant			New plant	
		Number assigned	Number filled	Position description	Position description/duties	Number needed
Supervisor, General Engineer (General Manager, PUP)	GM-14	1	1	Is responsible for sufficiency of all work at PUP.	Unchanged.	1
Supervisor, Mechanical Engineer (New Construction)	GS-14	2	2	Provides technical assistance to PUP General Manager. (Note: Position description not available.)	Not required.	0
Supervisor, Mechanical Engineering (Operations and Maintenance Manager, Control Manager, Supplies Manager)	GM-13	1	1	Is responsible for management control of day-to-day plant and maintenance operations. Ensures plant is operated in accordance with programs and budget. Upgrades operating and maintenance procedures.	Unchanged. Assigned as Operations and Maintenance Manager.	1
Supervisor, Plant Operations Assistant	GS-7	1	1	Is principal administrative assistant to General Manager. Assures/approves office procedures and supervises clerical staff.	Not required.	0
Management Assistant (Program Management Analyst)	GS-9	1	1	Is responsible for the maintenance, update, administration, and input of preventive maintenance data and inventory into plant data base. Produces report for preventive maintenance. Creates work orders. Initiates order for procurement.	Unchanged. Assigned as Management Assistant, Data Base.	1
Supervisor, Mechanical Engineering	GM-13	1	1	Determines need for contract support services. Develops work packages, specifications, and contracts for outside services and supplies.	Not required. Contract administration assistance to be provided by the Federal Facilities Division.	0

Table 4-1.
Comparison of Management and Administrative Staff Positions for PUP and NHRP

Position	Grade	Existing plant			New plant	
		Number assigned	Number filled	Position description	Position description/duties	Number needed
Supply Technician	GS-7	1	1	Maintains, on an automated system, the plant administrative and operating data and inventory of spare parts, supplies, and tools. Controls plant stores and analyzes trends on equipment life and failures. Prepares and manages annual fuel plan.	Duties to be assumed by management assistant or upgraded clerk typist.	0
Clerk Typist	GS-5	2	1	Completes reports, including fuels, water, boiler performance, and chilled water performance. Checks accuracy of fuel oil inventory. Prepares time reports, costs of material from job tickets.	Unchanged. Upgrade position to GS-7 if assigned duties to maintain plant operating data and inventory, as performed by PUP supply technician.	2
Motor Vehicle Operator	WG-6	1	1	Is responsible for operation, preventive maintenance, and servicing of automotive trucks. Drive trucks to haul supplies, materials, equipment, and personnel. Loads and unloads trucks.	Not required. Services to be obtained from the Federal Facilities Division.	0

Table 4-2.
Comparison of Operations Staff Positions for PUP and NHRP

Position	Grade	Existing plant			New plant	
		Number assigned	Number filled	Position description	Position description/duties	Number needed
Utilities Systems Repair Operator (USRO) Foreman	WS-10	6	5	Serves as shift supervisor. Supervises wage grade employees (electricians, machinists, and USROs) in operation and maintenance of plant. Schedules preventive maintenance, prioritizes work orders, assigns crew members. Reviews completed work orders.	Must be knowledgeable of computer systems operations. Will concentrate on plant operations; administration of preventive maintenance is by General Foreman.	5(1)
Utility Systems Repair Operator	WG-11	6	6	Independently operates all systems in the plant, including start-up and shutdown. Monitors critical operating levels. Operates systems such as steam, condensate, feedwater, condenser water, water softener, and compressed air.	Unchanged. Personnel mix may include WG-11, WL-10, and WG-10 from next two position types.	5(2)
Utility Systems Repair Operator (Operations)	WL-10	6	4	Operates systems including start-up, operation, and shutdown. Monitors critical operating parameters. Performs preventive maintenance. Trains lower grade employees.	Not required. Duties to be combined with previous position type.	0
Utility Systems Repair Operator (Operations)	WG-10	6	2	Operates equipment at the component level. Monitors operating parameters. Operates most plant systems. Monitors critical operating parameters.	Not required. Duties to be combined with previous position type.	0
Computer Systems Specialist	GS-12	0	0	Is responsible for software modifications, program debugging, and technical direction and training of operation staff.	New position.	1

Notes: (1) Based on three eight-hour shifts per day, seven days per week, and normal work week of five eight-hour shifts; need four crews plus one floating crew. Allowing for annual vacations and periodic training, five crews are recommended. USRO foreman will also man control room. (2) Shift crew will include one USRO, one repair mechanic, and one electrician under the direction of the USRO foreman.

Table 4-3.
Comparison of General and Assistant General Foremen Positions for PUP and NHRP

Position	Grade	Existing plant			New plant	
		Number assigned	Number filled	Position description	Position description/duties	Number needed
Utility Systems Repairer Operator (USRO) General Foreman	WS-16	1	1	Is responsible for day-to-day operation, maintenance, and repair of PUP. Plans and schedules work assignments. Develops quality standards. Administers management programs such as safety, cost, and incentive awards.	Provides technical direction for maintenance and repair. Other duties unchanged.	1
Utility Systems Repairer Operator (USRO) Assistant General Foreman	WS-15	1	1	Assists General Foreman. Plans and schedules work assignments on a long-range basis. Assigns work requirements to subordinates. Acts on personnel problems. Maintains production reports and administrative records.	Not required.	0

Table 4-4.
Comparison of Maintenance Department Staff Positions for PUP and NHRP

Position	Grade	Existing plant			New plant	
		Number assigned	Number filled	Position description	Position description/duties	Number needed
Machinist Foreman and Repair Foreman	WS-11	2	1	Plans, coordinates, and supervises the activities of repair and maintenance of heating and refrigeration equipment. Plans work for the shop. Organizes crews for assigned work.	Not required. Duties performed by USRO General Foreman.	0
Machinist Leader	WL-11 WG-11	2 3	2 0	Performs general machinist work. Disassembles, repairs, reassembles, and tests major equipment. Assists Machinist Foreman. Leads repair crews.	Not required. Duties performed by USRO General Foreman.	0
Pipefitter-Welder	WG-11	4	3	Performs all tasks in the cutting and welding of pipe. Lays out piping arrangements. Repairs and maintains valves. Performs welding in all positions in accordance with ASME. Welds iron, stainless steel, brass, cooper, aluminum, etc.	Unchanged.	4
Pipefitter	WG-10	2	1	Performs all tasks in cutting and fitting of pipes. Repairs and maintains valves.	Not required. Duties performed by previous position type.	0
Utility Systems Repair Operator (USRO) Leader, Repairs	WL-10	1	1	Leads the troubleshooting of equipment problems, identifies needed repairs, conducts repairs, and runs tests. Trains lower grade employees to diagnose problems and perform necessary work to restore equipment. Works in operations in instances of personnel shortages.	Not required. Duties shared by USRO General Foreman and more experienced repair mechanics.	0

Table 4-4.
Comparison of Maintenance Department Staff Positions for PUP and NHRP

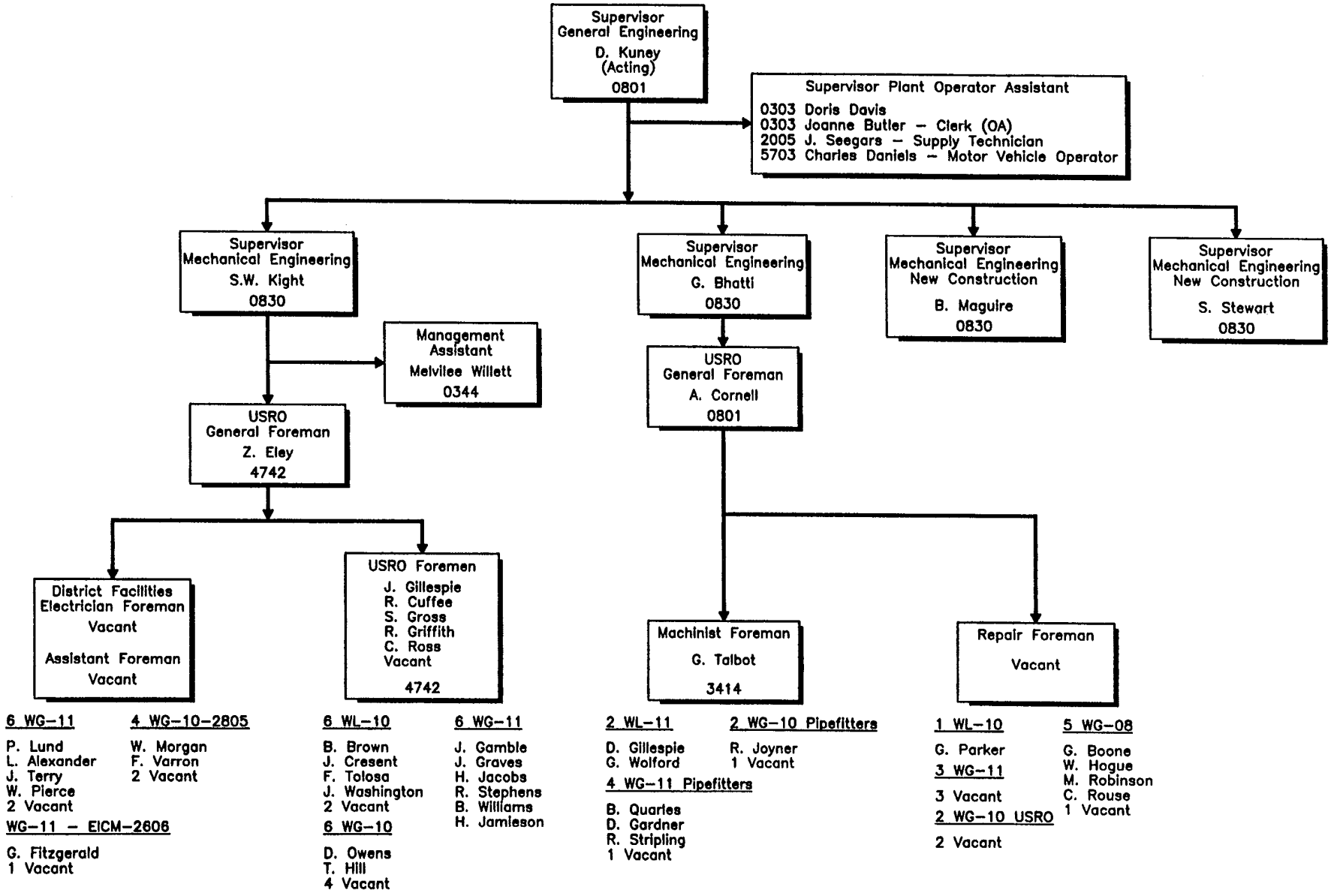
Position	Grade	Existing plant			New plant	
		Number assigned	Number filled	Position description	Position description/duties	Number needed
Utilities System Repair Operator (USRO), Repair Mechanic	WG-10	2	0	Independently, or with minimal supervision, troubleshoots most problems with equipment, identifies needed repairs, and conducts repairs of large boiler and refrigeration plant equipment.	Unchanged. One assigned per shift; may include WG-8 personnel.	5
Utility Systems Repair Operator (USRO), Repair and Operations	WG-8	5	4	Under supervision of higher grade USROs, operates heating and refrigeration systems. Visually inspects equipment and records operating data. Performs minor system repairs.	Not required. Duties combined with previous position type.	0

Table 4-5.
Comparison of Electrical Distribution Facilities Staff Positions for PUP and NHRP

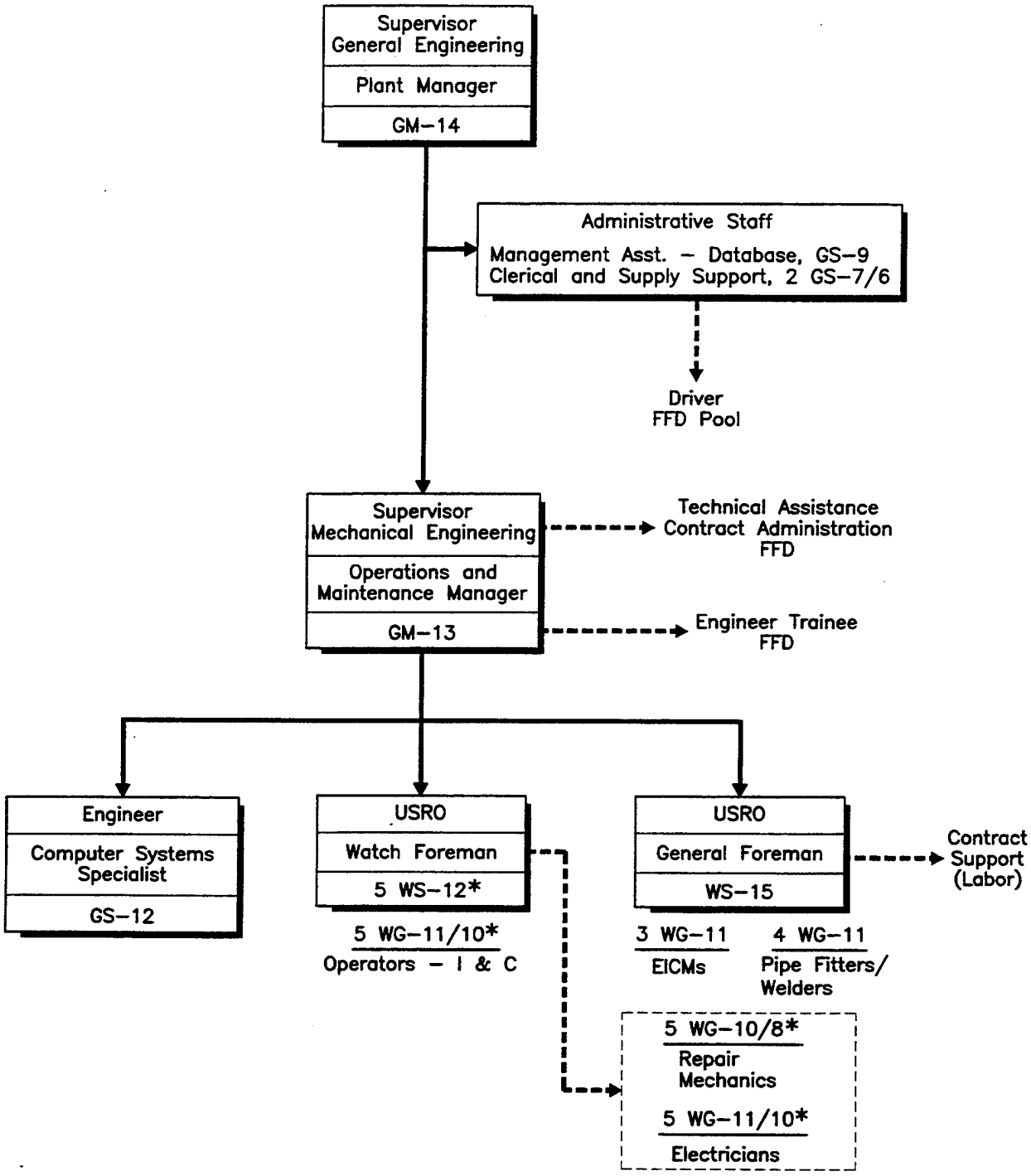
Position	Grade	Existing plant			New plant	
		Number assigned	Number filled	Position description	Position description/duties	Number needed
Distribution Facility Electrician Foreman	WS-11	1	0	Plans, coordinates, directs, or inspects activities of electricians and electronic industrial controls mechanics. Evaluates repair requirements, organizes work crews, and provides technical instructions. Reviews specifications for repairs performed by contractor.	Not required.	0
Electrician Leader (Assistant Foreman)	WL-10	1	0	Leads group of electricians, electronic/ pneumatic personnel, and helpers engaged in installation, repair, maintenance, and systems. Locates, diagnoses, and repairs electrical equipment. Assists Electrician Foreman.	Not required.	0
Electronic Industrial Controls Mechanic	WG-11	2	1	Installs new electronic devices and instruments. Inspects, calibrates, and performs maintenance of indicating and recording instruments and control systems.	Position expanded to include responsibility for computer-based systems.	3
Distribution Facilities Electrician	WG-11	6	4	Works in the maintenance and repair of electrical equipment, feeder and distribution lines, circuits, transformers, circuit breakers, switches, etc. Operates high and low voltage control panels. Inspects and adjusts electrical equipment.	Assigned to shift. Will be responsible for routine maintenance of emergency diesel generator. Duties will include those of electrician below. Electrician, WG-10 below, can be included in assignment.	5

Table 4-5.
Comparison of Electrical Distribution Facilities Staff Positions for PUP and NHRP

Position	Grade	Existing plant			New plant	
		Number assigned	Number filled	Position description	Position description/duties	Number needed
Electrician	WG-10	4	2	Plans and lays out work from prints, sketches, wiring diagrams. Locates electrical shorts, diagnoses trouble, and repairs electrical equipment such as lighting, air conditioning and heating, public address systems, fans, motors, and distribution panels.	Not required. Duties combined with previous position type.	0



Pentagon Utilities Plant
Organization 3/29/94
Figure 4-1



Priority of Work for Shift Personnel is Assigned by Watch Foreman

**Shift Personnel = 20*
Total Personnel = 34

Figure 4-2 Pentagon New Heating And Refrigeration Plant - Proposed Organization

Rev 8/23/94

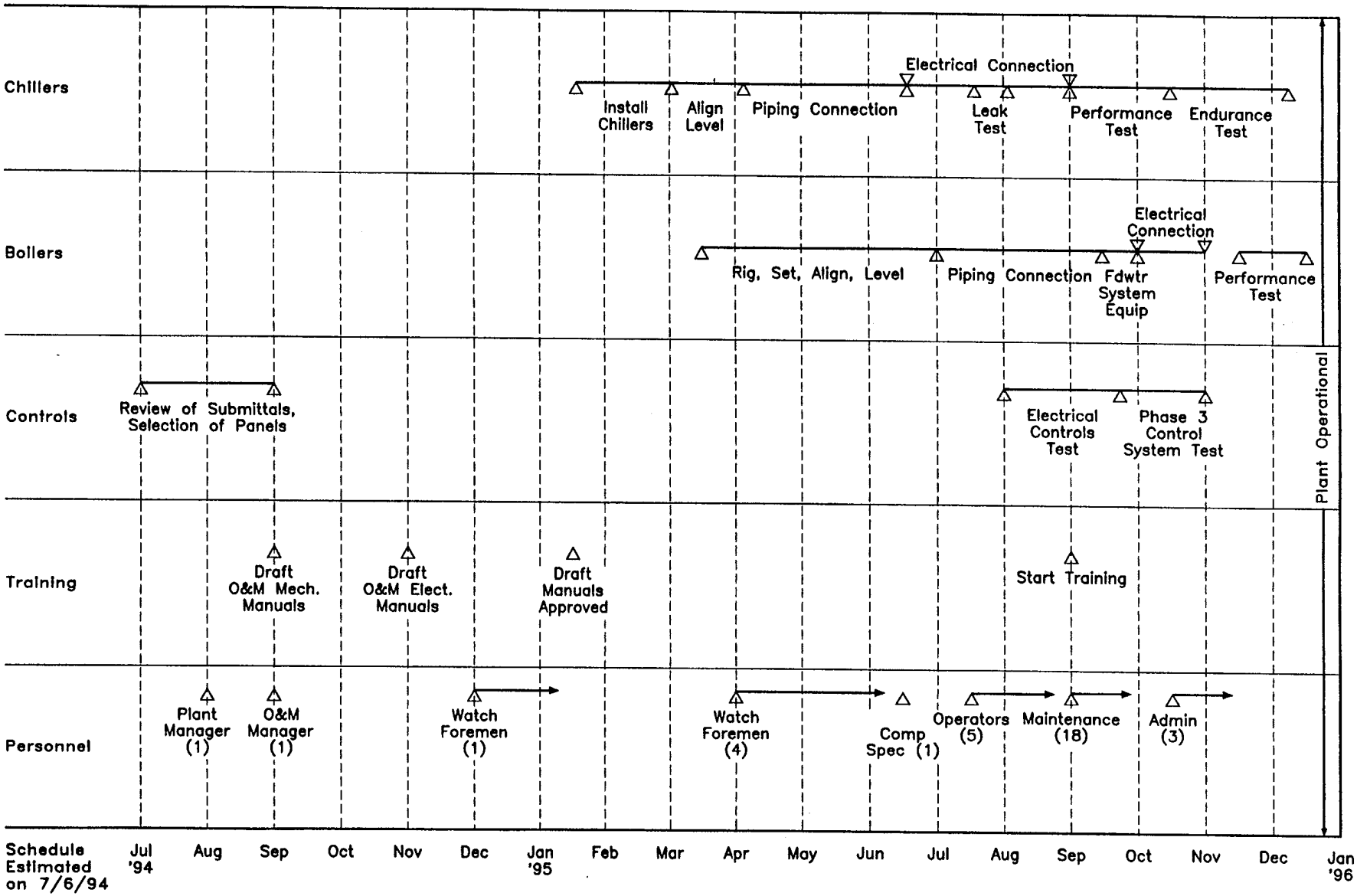


Figure 4-3. Pentagon New Heating And Refrigeration Plant Schedule Of Key Events For Major Equipment And Recommended Schedule For Personnel Staffing

Rev 8/12/94

CHAPTER 5

Training Requirements

This chapter reviews the provisions in the construction specification for training NHRP staff, identifies training voids, and it presents a detailed outline for a training program plan.

EXISTING PROVISIONS FOR TRAINING

This section reviews the training provisions in the construction specification. It also identifies weaknesses in the planned training program.

Equipment Training

The construction specification requires that the equipment suppliers train NHRP staff on-site in the operation and maintenance of their equipment. Those requirements are summarized in Table 5-1. The extent of training varies from 8 hours for pumps to more than 120 hours for the central distributed control system. Generally, the suppliers are supposed to conduct the training after the system is functionally complete but before final acceptance testing. The construction manager, Bell-BCI, has indicated that it plans to schedule training by the equipment suppliers from September to December 1995 (the current schedule calls for plant start-up on December 19, 1995).

A review of the training requirements in Table 5-1 and of the time frame proposed by Bell-BCI indicates that the training period is marginally adequate. The proposed training totals 448 hours (approximately 58 days). Between September 5, 1995, when training is assumed to start, and December 19, 1995, when plant start-up is scheduled, there are approximately 73 weekdays (excluding holidays). Not all of the days will be available for training because key personnel will be participating in system tests as well as in administrative training. Therefore, we believe that training should be initiated no later than August 1, 1995. This would add 22 days making a total of 95 days available for training NHRP personnel.

Operations and Maintenance Manuals

The construction specification requires suppliers to provide operating instructions and operations and maintenance manuals. Table 5-2 summarizes the support documents required by the specification. Bell-BCI has indicated that it plans to compile the individual equipment documents provided by the suppliers

into operations and maintenance manuals. It expects to have the first draft of the manuals for mechanical equipment by early September 1994 and for electrical equipment by November 1, 1994. The drafts are for review by the government; final versions are to be issued by the end of January 1995.

Because, the training program is weighted heavily toward on-the-job training, the materials used should be of high caliber to ensure that the training by the vendors' personnel results in correct operation of the equipment. The construction specification contains requirements as to the content of the training materials, but does not specify a standard format and content, nor does it call for training aids such as sketches of the equipment to facilitate an understanding of the individual components. It is probably too late, and therefore not economically feasible, to change the specification, so the training program should use the contractors submittals as is. However, training aids should be added to fill in obvious voids.

Although the manuals to be prepared by Bell-BCI will be necessary for training, they do not provide an integrated understanding of the functioning of the overall system and the controls. This level of information requires systems description manuals, but no provisions have yet been made to obtain these. Efforts should be initiated as soon as possible to ensure that systems description and operation manuals are available for use by the time training is started. Early availability of such manuals not only will provide personnel the details of system functioning, but also will enable a hands-on review and upgrade/revision of the written descriptions as part of the process of walkdowns and trial operation.

Plant Systems Training

Bell-BCI has indicated that it plans to provide general training covering plant systems during the September-December 1995 training phase. That training will consist of a review of the plant arrangement and system drawings but will not include instructions in plant operation.

It appears that the NHRP staff will have to develop its own operating procedures on the basis of the training received on the individual equipment, the operations and maintenance manuals provided by the equipment suppliers, the system descriptions, and experience gained during the start-up performance test period. If senior plant management, the operations and maintenance manager, and watch foremen are brought onboard well in advance of plant operation, they can direct their efforts to the preparation of operating procedures and a long-term training program.

Prerequisites to Control System Training

The construction specification for the central distributed control system (Section 16950) requires the contractor to identify training, knowledge, or skill prerequisites that personnel must have before they receive control system training.

In view of the significant difference in technology between the PUP and the NHRP control systems, PUP personnel may need to undertake special training to meet the prerequisites. Such training may take several months to set up and conduct.

When this report was written, the contractor for the NHRP control system had not yet identified the prerequisites for training. In view of the lead time required for any special training of PUP personnel, the contractor should identify the prerequisites as soon as possible. (The prerequisites for training are not necessarily contained in the position descriptions; these specify the skill and knowledge requirements to actually perform the job, which presumably would be attained after appropriate training.)

TRAINING VOIDS

Plant Administration

The existing training program contains only equipment modules. Additional courses relating to conduct of operations, industrial safety and management, procedures guides, emergency procedures, safety tagging (lockout and tagout), supervision, administrative procedures, etc., should be included in order to have a complete training program.

Diesel Generators

At present, the construction specification does not provide for training in the operation of the diesel generators. We understand that the general subject of emergency power is being evaluated. As soon as a decision is made, appropriate training should be planned and incorporated into the plant operations training.

TRAINING PROGRAM PLAN

The training program plan we had hoped to develop by this time would be very detailed and coordinate specific schedules between the equipment vendors, Bell-BCI, and NHRP staff. The component installation schedules and contents of the vendors training modules have not been forthcoming at this time so we have suggested a training program plan outlined in Table 5-3, arranged by system and equipment. The plan includes schedules, length of instruction, and responsible organizations. The plan outline has its basis in the scope of training defined in the construction specification and can serve as the basis for the development of a comprehensive training program plan when detailed information is available. Essential input for the detailed plan includes the schedules for construction completition, flushing, hydrotests, and electrical checks, as well as a defined scope of vendor instruction. Priority should be given to the preparation of the detailed training program that fits in with the startup schedule to ensure maximum

benefits are obtained during the limited tithe eguipment is in a pre-operational status.

Table 5-4 shows the total number of hours of training required for each job position; Appendix E lists the training hours by system for each position. The length of time (contact hours) that should be allocated for personnel training can be used in planning augmentation rates and nontraining job assignments during the training phase.

The bulk of the training in the plan occurs from September through December 1995, following the Bell-BCI schedule. If the training period is started in August, as we have suggested, the tables should be adjusted accordingly. As shown on the recommended schedule for personnel staffing on Figure 4-3, plant managers, shift foremen, and operators should be assigned by the beginning of the training period, and maintenance personnel, particularly those requiring skills that may not be currently available at the PUP, such as the EICMs, should be brought onboard early in the training period.

The plan includes the following additional training that is needed, but not included in the construction specification:

- For all NHRP personnel, a general orientation of the plant, including an overview of the plant systems followed by a walkdown of plant areas.
- For EICMs and the computer systems specialist, hardware and software development training. That training should be conducted from June to December 1995 and periodically during the evolution of computer systems installation tests and modifications.
- For each member of the operating crew, integrated, hands-on plant control training. (As currently scheduled, operator training is limited to classroom teaching only and to 10 people only; use of a training simulator for this purpose would be most effective.)

The length of training indicated in the construction specification for some of the plant support systems could be reduced, particularly if scheduling becomes a problem. The allocated time for the plant (internal) heating, air conditioning, ventilation, and exhaust systems and for the intrusion detection, entry control, and fire detection systems appears to be longer than necessary. This should be reevaluated when the operations and maintenance manuals for these systems are reviewed.

SIMULATOR TRAINING

Recent experience at new power plants incorporating extensive distributed control systems, as well as at existing plants with control system retrofits, has shown positive benefits from with the use of simulators for training. The cost and effort of providing a simulator for a computer-based control system is much

lower than for an analog system since many of the same digital algorithms used to control the plant can be used to run the simulator.

For the NHRP, a simulator would provide not only training (both for before start-up as well as for the long term) but also a platform for staffing studies for operations. In addition, needed changes to software and display screens identified in training activities could be made as part of the control system debugging process if the simulator is obtained early , (during evolution of the system design) evolution. This debugging process would be expected to identify first-time design implementation and minimize plant start-up delays and damage to equipment.

Since involvement by the controls system designer and by the suppliers of the major equipment (boilers and chillers) would be necessary, the most opportune time for the development of the simulator is now. We recommend, as a minimum, that steps be taken as soon as possible to determine the costs and benefits of having a simulator for NHRP.

Table 5-1

Pentagon Heating and Refrigeration Plant
Summary of Existing Training Requirements

System/ Component	Section/ Paragraph	Contact Hours	Training
Central Steam Generating System - Combination Gas and Oil Fired, includes boilers, burners, economizers, sootblowers, feedwater regulator, fuel oil heaters, forced draft fans, flame safety equipment and controls, condensate transfer and lift pumps, deaerators, boiler feedwater pumps, chemical feed system, continuous blowdown system, fuel oil transfer system, and water softening and condensate polishing equipment	15561/3.8	Not specified. 36 hours suggested.	A field training course shall be conducted for the maintenance and operating staff. Training shall include all items contained in the operating and maintenance instructions, including demonstrations of routine maintenance operations. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.
Water Chillers, including unit central panel, primary compressor, speed increaser gear set, primary motor, cooler, condenser intercooler	15680/3.3	Not specified. 8 hours suggested. 16 16 8	A representative of the chiller manufacturer shall train operating personnel in the proper operating and maintenance of the unit. Training sessions shall be scheduled for a period of four hours each day for each of three rotating shifts. Specific training to be conducted includes: · Chiller and chiller controls operator and maintenance training. Training manuals shall be provided. Assume attendees have a high school education or equivalent and are familiar with HVAC systems. · Chiller Unit Control Panel (UCP) hardware and software training. The first course shall be taught on-site for four consecutive days during field testing activities. Four personnel per shift will attend this course. Course shall include general controls hardware architecture, functional operation of the system, operator commands, control sequence programming, data base entry, reports and logs, and diagnostics. · Advanced operator training. This shall be a hands-on course taught on-site for four consecutive days, and shall be conducted during field test activities; a specified amount of training shall be conducted during endurance testing. Two personnel per shift will attend this course. Upon completion of this course, students should be fully proficient in the operation of all systems. · Maintenance training. This shall be a two-day course taught at the project site after completion of endurance tests. Six personnel per shift will attend the course. Training shall include physical layout of each piece of hardware, troubleshooting and diagnostics procedures, repair instructions, preventive maintenance procedures and schedules, and calibration procedures.

Table 5-1

Pentagon Heating and Refrigeration Plant
Summary of Existing Training Requirements

System/ Component	Section/ Paragraph	Contact Hours	Training
Centrifugal Water Pumps, including chilled water distribution, chiller loop circulation, screen wash, fire and pressure maintenance pumps	11211/3.5	8	One or more engineers shall provide field instruction to a Government representative for a period of at least 8 hours in the operation and maintenance of centrifugal water pumps.
Vertical Turbine Water Pumps, including condenser circ water, and sump dewatering pumps	11212/3.5	8	An eight-hour training course shall be conducted for the maintenance and operating staff. Training should include all items contained in the operating and maintenance instructions, including demonstrations of routine maintenance operations. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.
Sluice Gates	11202/3.3.1	?	Onsite instruction shall be provided in the operation and maintenance of sluice gates and actuators.
Compressed Air Equipment	15400-54	8	The contractor shall provide the onsite services of a factory representative to instruct the user in the startup, operation and maintenance of the equipment. Training shall be performed within 30 days after completion of performance verification testing.
Main Electrical Supply Station Power Transformers	16311/3.7	16	A 16-hour field training course on operation and maintenance of station equipment shall be conducted for representatives of the using agency following completion of field tests.
Underground Electrical Distribution System	16375/3.14	Not specified. 8 hours	Training shall be provided in the startup, operation, and maintenance of the secondary unit substation transformer and metal-enclosed interrupter switchgear.
Interior Electrical Work	16415/3.27	16	Two 8-hour field training sessions on operation and maintenance of the following equipment shall be conducted for representatives of the using agency after completion of field tests: · Station battery system · Metal-clad switchgear · 480 volt MCCs · 4.16 kV MCCs · Load centers

Table 5-1

Pentagon Heating and Refrigeration Plant
Summary of Existing Training Requirements

System/ Component	Section/ Paragraph	Contact Hours	Training
Central Distributed Control System	16950/3.5	40	The following training courses shall be provided for designated personnel in the operation and maintenance of the DCS; assume attendees are tradesmen such as electrician or boiler operators: • Operator's Training I. This course shall be taught on-site for 5 consecutive days at least three months prior to performance verification tests. A maximum of 10 personnel will attend this course. The course should enable trainees to perform elementary operations with guidance and describe the general hardware architecture and functionality of the system. The following shall be included: - general system architecture - functional operation of the system - operator commands - use and implementation of application programs, control sequences and control loops - color graphics generation - database entry and modification, including databases required for communications - reports generation - alarm reporting - diagnostics - use of central operator station
		40	
		16	• Operator's Training II. This on-site course shall be taught over consecutive days during or after field testing, but prior to performance verification tests. A maximum of 10 personnel will attend this course. Upon completion of this course, each student should be able to start and operate the system, recover from a failure, and describe specific hardware architecture and operation of the system. • Operator's Training III. This hands-on course shall provide 16 hours of instruction per student for a maximum of 10 students, and shall be taught while endurance testing is in progress. The schedule shall allow for each student to receive individual instruction for a 4-hour period in the morning or afternoon of the same weekday for four consecutive weeks. Upon completion of this course, students should be proficient in system operations.

Table 5-1

Pentagon Heating and Refrigeration Plant
Summary of Existing Training Requirements

System/ Component	Section/ Paragraph	Contact Hours	Training
Central Distributed Control System, Cont'd	16950/3.4	24	· Operator's Training IV. This 3-day course shall be taught at the project site after completion of opposite season testing, or no later than six months after completion of endurance tests. A maximum of 10 personnel will attend. Upon completion, students shall be proficient in system operation and have no unanswered questions regarding operation of the installed DCS.
		40	· Software Maintenance and Development Training. This five day course shall be taught over consecutive days and shall provide detailed instruction for maintaining the DCS database system and operations programs, and modifying or extending their capabilities. The course shall be taught on-site at least 30 days prior to scheduled performance verification tests. A minimum of 4 hours instruction shall be provided for each of the following topics: · use of database routines · interpretation of reports · use of existing programs to modify databases · program PLCs · add subroutines to the DCS programs · design and add graphics screens · compile modified programs · demonstration of sample subroutines.
Instrument Installation	16900/3.6	8	Written operating instructions and not less than eight hours of operator training shall be provided.
Sewage and Sump Pumps (For Plant and Tunnel Applications)	11310/3.6	8	A factory representative shall provide eight hours of on-site instruction on the startup, operation, and maintenance of all sewage and sump pumps. Training shall include all items contained in the operating and maintenance manuals. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.
Forced Hot Water Heating Systems Using Steam Heat Exchangers	15556/3.20	16	A sixteen-hour field training course shall be conducted for operating and maintenance staff. Training shall include all items contained in the operating and maintenance manuals. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.
Central Refrigerated Air Conditioning System	15650/3.8	8	An eight-hour field training course shall be conducted for the operating staff. Training shall include all items contained in the operating and maintenance instructions, including demonstrations of routine maintenance operations. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.

Table 5-1

Pentagon Heating and Refrigeration Plant
Summary of Existing Training Requirements

System/ Component	Section/ Paragraph	Contact Hours	Training
Air Supply and Distribution System (for air conditioning system)	15895/1.5	40	A forty-hour field training course shall be conducted for the operating staff. Training shall include all items contained in the operating and maintenance instructions, including demonstrations of routine maintenance operations. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.
Ventilation and Exhaust Systems	15935/3.4	24	A 24-hour training course shall be conducted for the operating and maintenance staff. Training shall include all items contained in the operating and maintenance instructions. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.
Heating, Ventilating and Air Conditioning Control Systems	15950/3.6	32	A 32-hour training course shall be conducted for the operating staff. Training shall include all items contained in the operating and maintenance instructions, the layout and location of each HVAC control panel, the layout of one of each type of unitary equipment and the locations of each, the location of each system control device external to the panels, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment commissioning, tuning and repair procedures. Results of performance verification tests and the calibration, adjustment and commissioning report shall be presented as benchmarks of HVAC system performance by which to measure operation and maintenance effectiveness.
Hydraulic Elevators	14240/3.6	8	An eight-hour field training course shall be conducted for the maintenance and operating staff. Training shall include all items contained in the operating and maintenance manuals. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.
Electric Overhead Traveling Cranes (Top Running and Overhung, 30 Ton Max)	14630/3.4.1	8	A field training course not less than 8 hours in duration shall be conducted for operating staff. Training shall include all items contained in the operating and maintenance instructions. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.
Monorails and Hoists	14640/3.7.1	?	A field training course shall be conducted for operating staff. Training shall include all items contained in the operating and maintenance instructions.

Table 5-1

Pentagon Heating and Refrigeration Plant
Summary of Existing Training Requirements

System/ Component	Section/ Paragraph	Contact Hours	Training
Intrusion Detection Systems (IDS)	16725/3.6	16	The following training courses shall be provided for designated personnel in the operation and maintenance of the IDS; assume attendees have a high school education or equivalent and are familiar with IDS's: • Operator's Training I. This course shall be taught on-site for two consecutive days at least three months prior to performance verification tests. A maximum of 12 personnel will attend this course. The course should enable trainees to perform elementary operations with guidance and describe the general hardware architecture and functionality of the system. The following shall be included: - general IDS hardware architecture - functional operation of the system - operator commands - database entry - alarm reporting - diagnostics.
		8	• Operator's Training II. This one-day, on-site course shall be taught during or after field testing, but prior to performance verification tests. A maximum of 12 personnel will attend this course. This course shall include specific instruction for operating the installed system. Upon completion of this course, each student should be able to start and operate the system, recover from a failure, and describe specific hardware architecture and operation of the system.
		4	• Operator's Training III. This hands-on course shall provide 4 hours of instruction per student for a maximum of 12 students, and shall be taught while endurance testing is in progress. The schedule shall allow for each student to receive individual instruction for a 4-hour period in the morning or afternoon of the same weekday (?). Upon completion of this course, students should be proficient in system operation.
		24	• Maintenance Personnel Training. This 3-day system maintenance course shall be taught at the project site after completion of endurance tests. A maximum of five personnel will attend. Upon completion, students shall be proficient in system maintenance. Training shall include:

Table 5-1

Pentagon Heating and Refrigeration Plant
Summary of Existing Training Requirements

System/ Component	Section/ Paragraph	Contact Hours	Training
Electronic Entry Control Systems	16752/3.6		The following training courses shall be provided for designated personnel in the operation and maintenance of the EECS; assume attendees have a high school education or equivalent and are familiar with EECS:
		24	• Operator's Training I. This course shall be taught on-site for 3 consecutive days at least three months prior to performance verification tests. A maximum of 12 personnel will attend this course. The course should enable trainees to perform elementary operations with guidance and describe the general hardware architecture and functionality of the system. The following shall be included: - general EECS hardware architecture - functional operation of the system - operator commands - database entry - reports generation - alarm reporting - diagnostics.
		16	• Operator's Training II. This two-day, on-site course shall be taught during or after field testing, but prior to performance verification tests. A maximum of 12 personnel will attend this course. Upon completion of this course, each student should be able to start and operate the system, recover from a failure, and describe specific hardware architecture and operation of the system.
		12	• Operator's Training III. This hands-on course shall provide 12 hours of instruction per student for a maximum of 12 students, and shall be taught while endurance testing is in progress. The schedule shall allow for each student to receive individual instruction for a 4-hour period in the morning or afternoon of the same weekday (?). Upon completion of this course, students should be proficient in system operation.
		40	• Maintenance Personnel Training. This 5-day system maintenance course shall be taught at the project site after completion of endurance tests. A maximum of five personnel will attend. Upon completion, students shall be proficient in system maintenance. Training shall include:

Table 5-1

Pentagon Heating and Refrigeration Plant
Summary of Existing Training Requirements

System/ Component	Section/ Paragraph	Contact Hours	Training
Plant Paging System	16770/3.4	8	An 8-hour training course shall be provided for two members of the operating and maintenance staff after the system is functionally complete but prior to final acceptance tests. Training shall include all items contained in the operating and maintenance instructions, including demonstrations of routine maintenance operations.
Fire Detection and Alarm System	16721/3.8	24	A training course of three days' duration (8 hours/day) shall be conducted for the operating staff. Training shall include all items contained in the operating and maintenance instructions. Training shall be performed after the system is functionally complete, but prior to final acceptance testing.

Table 5-2

Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Central Steam Generating System - Combination Gas and Oil Fired, includes boilers, burners, economizers, sootblowers, feedwater regulator, fuel oil heaters, forced draft fans, flame safety equipment and controls, condensate transfer and lift pumps, deaerators, boiler feedwater pumps, chemical feed system, continuous blowdown system, fuel oil transfer system, and water softening and condensate polishing equipment	15561/3.8	Diagrams, instructions, and other operating information, including wiring and control diagrams showing the complete layout of the entire system, shall be provided. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely stopping and starting the system shall be provided. Instructions shall be provided in electronic format.	Complete copies of operation manuals for the Steam Generating System, Water Softening and Polishing System, and Fuel Oil Storage and Distribution System shall be provided outlining the step-by-step procedures required for system startup, operation and shutdown. Manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. Complete copies of maintenance manuals listing routing maintenance procedures, possible breakdown and repairs, and troubleshooting guides. Manuals shall include piping layout, equipment layout, and simplified wiring and control diagrams of the system as installed. Operation and maintenance manuals shall be approved prior to training.	Design data should be provided where applicable and include operating range, efficiency, set points, operating speeds, performance curves, and other information necessary to accurately define the item submitted.
Water Chillers, including unit central panel, primary compressor, speed increaser gear set, primary motor, cooler, condenser intercooler	15680/3.3	Instructions for operation, preventive maintenance and diagnostics shall be provided in electronic format and programmed into the unit control panel computer, control room operator workstations, and maintenance workstations.	Adequate operation and maintenance information shall be supplied for all equipment requiring maintenance or other attention. The vendor shall prepare a comprehensive operation and maintenance manual set for the equipment, including: • Equipment functional design manual • Job-specific hardware manual • Maintenance manual • Software manual • Operator's manual • Unit control panel manual • Test data & performance curves	Operator & Maintenance training manuals shall be provided for each trainee that include an agenda, defined objectives for each lesson, and a detailed description of subject matter for each lesson.
Centrifugal Water Pumps, including chilled water distribution, chiller loop circulation, screen wash, fire and pressure maintenance pumps	11211/3.5	Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely stopping and starting the system shall be provided in electronic format.	Complete sets of manuals containing the manufacturer's operating and maintenance instructions for each piece of equipment. Among other requirements, manuals shall include (1) system layout, showing piping, valves, and controls, (2) a control sequence describing startup, operation and shutdown, and (3) operating and maintenance instructions for each piece of equipment, including lubrication instructions and trouble-shooting guide.	None

Table 5-2

Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Vertical Turbine Water Pumps, including condenser circ water, and sump dewatering pumps	11212/3.5	Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely stopping and starting the system shall be provided in electronic format for the wiring and control diagrams. Proposed diagrams, instructions, and other pertinent information shall be provided.	Operating manuals outlining the step-by-step procedures required for system startup, operation and shutdown. The manual shall include a brief description of all equipment and their basic operating features. Maintenance manuals listing routing maintenance procedures, possible breakdown and repairs, and troubleshooting guide. Manuals shall include simplified wiring, layout, and control diagrams of the system as installed. Operation and maintenance manuals shall be approved prior to training.	None
Sluice Gates	11202/3.3.1	Instructions showing the complete layout of the sluice gates and actuators shall be provided in electronic format. Condensed operating instructions explaining preventive maintenance procedures and methods for checking the system for normal safe operation shall be prepared.	Operation and maintenance manuals shall include instructions outlining the step-by-step procedure required for sluice gate and actuator operation. Instructions shall include a brief description of all equipment and their basic operating features. Maintenance instructions shall list routine maintenance procedures, possible breakdowns, and repairs.	Detail drawings shall be submitted and shall consist of illustrations, performance charts, instructions, brochures, diagrams and other information to illustrate the requirements and operation of the sluice gates and actuators.
Compressed Air Equipment	15400/3.12	Instructions including wiring and control diagrams showing the layout of the compressed air system and domestic water heater shall be provided in electronic format. Condensed operating instructions explaining preventive maintenance procedures, methods for checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared.	Operation and maintenance manuals shall include instructions outlining the step-by-step procedures required for system startup, operation and shutdown. Brief descriptions of all equipment and their basic operating features shall be included. Maintenance instructions shall list routine maintenance procedures, possible breakdowns, and repairs.	None
Main Electrical Supply Station Power Transformers	16311/3.7	Instruction manuals shall include assembly, installation, operation and maintenance instructions, among other items.	Operation and maintenance manuals shall include data outlining step-by-step procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective actions to be taken. A brief description of all equipment and their basic operating features shall be included.	None
Underground Electrical Distribution System	16375/3.14	None	Operation and maintenance manuals shall include data outlining step-by-step procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective actions to be taken. A brief description of all equipment and their basic operating features shall be included.	Detail scale or dimensioned drawings shall be submitted that show physical arrangement, construction details, access requirements for installation and maintenance, among other items.

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Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Interior Electrical Work	16415/3.27	None	Operation and maintenance manuals shall include, among other items, the following: (1) Approved wiring, control, and one-line diagrams with control sequence descriptions, (2) Operation and maintenance instructions for each piece of equipment, including a troubleshooting guide, and (3) Manufacturer's bulletins, catalog cuts, descriptive data, parts list and recommended spare parts.	Detail drawings shall be submitted for all materials and equipment specified, with one-line and three-line diagrams, schematics, wiring diagrams, conduit and cable tray runs, as well as other items. A one line diagram showing the overall electrical system shall be submitted that shows, as a minimum, switchgear, 5 kV MCCs and load centers and their respective loads.
Central Distributed Control System	16950/3.5	None	Operation and maintenance manuals shall include, among other information, step-by-step procedures required for each control system's startup, operation and shutdown; all detail drawings and equipment data; each controller's configuration check sheet; manufacturer-supplied operation manuals for all equipment; maintenance manuals, indexed in booklet form listing maintenance procedures; maintenance instructions, including a maintenance checklist for each control system; maintenance manuals, including spare parts data and recommended maintenance tool kits for all control devices; and maintenance instructions, including recommended repair methods (i.e., field repair, factory repair or whole item replacement). Operating and maintenance manuals shall be provided for each type of software. Operation manuals shall be provided for the controls software in each PC and PLC, that fully describe each system and program configuration, and give several examples of user modifications available, including clear instructions of procedures to facilitate or modify current configurations. Commissioning procedures shall be provided that include general instructions on how to set control parameters, including setpoints; proportional, integral and derivative mode constants; and contact output settings for the specific devices provided.	A training course in the maintenance and operation of the control systems shall be specified 60 days prior to start of training. Training manuals shall be provided that identify the agenda, and defined objectives and detailed description of the subject matter for each lesson. Equipment data shall be indexed and in booklet form. Drawings shall include a drawing index, a list of symbols, a series of drawings for each control system and control device schedules. Each series of drawings for a control system shall include schematics, ladder diagrams, equipment schedules, wiring diagrams, control panel arrangement drawings, and a control system sequence of operation.

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Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Instrument Installation	16900/3.6	Written operating instructions shall be provided.	Operation and maintenance manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures, and safety precautions.	Instructional materials belonging to the manufacturer or vendor, e.g., lists, static exhibits, and visual aids, shall be made available to the Contracting Officer.
Sewage and Sump Pumps (For Plant and Tunnel Applications)	11310/3.6	Diagrams, instructions and other pertinent information shall be provided. Instructions containing wiring and control diagrams shall be provided in electronic format. Condensed operating instructions explaining preventive maintenance procedures and methods for checking the system for normal safe operation shall be provided.	Operation and maintenance manuals shall include instructions outlining the step-by-step procedures required for system startup, operation and shutdown. Brief descriptions of all equipment and their basic operating features shall be included. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include piping and equipment layout and simplified wiring and control diagrams of the system.	None
Forced Hot Water Heating Systems Using Steam Heat Exchangers	15556/3.20	Instructions shall be provided in electronic format.	Operation and maintenance manuals shall include, but not be limited to, the following: (1) System layout showing piping, valves, equipment tag numbers, and controls, (2) Approved wiring and control diagrams, (3) Valve listing with all system valves identified by tag number, type of valve and size, (4) A control sequence describing startup, operation and shutdown, (5) Operation and maintenance instructions for each piece of equipment, including lubricating instructions and troubleshooting guide, and (6) manufacturer's bulletins, cuts, descriptive data, parts list and recommended spare parts.	Detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves.
Central Refrigerated Air Conditioning System	15650/3.8	Instructions shall be provided in electronic format including proposed diagrams. Instructions shall include wiring and control diagrams showing the complete layout of the entire system, including equipment, piping, valves, and control sequence, and condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system.	Operation and maintenance manuals shall outline the step-by-step procedures required for system startup, operation and shutdown. Brief descriptions of all equipment and their basic operating features shall be included. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.	Detail drawings consisting of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, performance charts and curves. Wiring diagrams shall be provided identifying each component and all interconnected or interlocked components.

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Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Air Supply and Distribution System (for air conditioning system)	15895/1.5	Instructions shall be provided in electronic format.	Operation and maintenance manuals shall include, but not be limited to, the following: (1) System layout showing ductwork, fans, air handling units, terminal units, piping, valves, equipment tag numbers, and controls, (2) Approved airflow, wiring and control diagrams, (3) Valve listing with all system valves identified by tag number, type of valve and size, (4) A control sequence describing startup, operation and shutdown, (5) Operation and maintenance instructions for each piece of equipment, including lubricating instructions and troubleshooting guide, and (6) Manufacturer's bulletins, cuts, descriptive data, parts list and recommended spare parts.	Fan performance curves for each fan shall be submitted, as well as a schedule of damper sizes for installation in sheet metal ductwork, together with leakage and flow characteristic charts. Drawings shall be submitted consisting of illustrations, schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate the requirements and operations of the system. Drawings shall include schematic automatic temperature and airflow control diagrams and control sequences.
Ventilation and Exhaust Systems	15935/3.4	Instructions shall be provided in electronic format.	Operation and maintenance manuals shall include, but not be limited to, the following: (1) System layout showing ductwork, control dampers, fans, and controls with equipment tag numbers, (2) Approved wiring and control diagrams, (3) Control sequences describing startup, operation and shutdown, (4) Airflow and control diagrams indicating airflows throughout the systems, equipment, and control devices, (5) Operation and maintenance instructions for each piece of equipment, including lubricating instructions and troubleshooting guide, and (6) Manufacturer's bulletins, cuts, descriptive data, parts list and recommended spare parts.	Illustrations, schedules, performance charts, instructions, brochures, diagrams and other information shall be submitted to illustrate the requirements and operation of the equipment and the system. A schedule of damper sizes for installation in exterior walls and sheet metal ductwork, together with leakage and flow characteristic charts.

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Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Heating, Ventilating and Air Conditioning Control Systems	15950/3.6	Instructions shall be provided in electronic format and shall include the control sequence, control schematic, ladder diagrams, wiring diagrams, valve schedules, damper schedules, panel arrangement drawings, commissioning procedures, controller configuration check sheet with final configuration record, preventive maintenance instructions, and single-loop controller operator's manual.	Operation and maintenance manuals for each HVAC control system shall outline the step-by-step procedures required for system startup, operation and shutdown. Manuals shall include detail drawings, equipment data, each controller's configuration check sheet, and manufacturer supplied operation manuals for all equipment. Maintenance instructions shall include a maintenance checklist for each HVAC control system, spare parts data and recommended maintenance tool kits for all control devices, and recommended repair methods (i.e., field repair, factory repair or whole item replacement). Commissioning procedures shall be provided that include step-by-step configuration procedures for each controller. Configuration procedures shall include a configuration check sheet showing all configuration parameters, dip switch settings, and initial recommended P, I and D constants. Commissioning procedures shall include general instructions on how to set control parameters, including set points; proportional, integral and derivative mode constants; and contact output settings for the specific devices provided.	Manufacturer's equipment data and product-specific catalog cuts. A training course program and manual in the maintenance and operation of the HVAC control systems shall be specified 60 days prior to start of training. Training manuals shall be provided that identify the agenda, and defined objectives and detailed description of the subject matter for each lesson. The contractor shall submit an outline for the training course, with a proposed time schedule.
Hydraulic Elevators	14240/3.6	Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, as well as wiring and control diagrams showing complete layout of the entire system.	Operation and maintenance manuals shall detail the step-by-step procedures required for system startup, operation and shutdown. Brief descriptions of all equipment and their basic operating features shall be included. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.	Drawings shall consist of complete list of equipment and materials, including illustrations, schedules, manufacturer's descriptive and technical literature, performance charts, catalog cuts, installation instructions, brochures, diagrams and other pertinent information. Detail drawings shall include dimensioned layouts in plan and elevation showing the arrangement of the elevator equipment.

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Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Electric Overhead Traveling Cranes (Top Running and Overhung, 30 Ton Max)	14630/3.4.1	Diagrams and maintenance and operational instructions shall be provided in electronic format.	Operation and maintenance manuals shall detail the step-by-step procedures required for system startup, operation and shutdown. Brief descriptions of all equipment and their basic operating features shall be included. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed. Manuals shall be approved prior to the field training course.	A complete list of equipment and materials, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts and installation instructions. Detail drawings containing complete wiring and schematic diagrams.
Monorails and Hoists	14640/3.7.1	Diagrams and maintenance and operational instructions shall be provided in electronic format.	Operation and maintenance manuals shall include, but not be limited to, brief descriptions of all equipment and their basic operating features, routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides.	A complete list of equipment and materials, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts and installation instructions.

Table 5-2

Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Intrusion Detection Systems (IDS)	16725/3.6	None	Operation and maintenance manuals shall include, but not be limited to, a hardware manual, software manual, operator's manual, and maintenance manual. The hardware manual shall describe all equipment furnished, including general descriptions and specifications, installation and checkout procedures, equipment electrical schematics and layout drawings, system schematics and layout drawings, alignment and calibration procedures, and interface definition. The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation, as well as definitions of terms and functions, use of system and applications software, procedures for initialization, startup and shutdown, and descriptions of all communications protocols. The operator's manual shall fully explain all procedures and instructions for operation of the system, including computers and peripherals, system startup and shutdown procedures, use of system, command and applications software, recovery and restart procedure, data entry, operator commands, alarm messages and printing formats, and system access requirements. The maintenance manual shall describe maintenance for all equipment, including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.	Data shall be submitted including but not limited to system descriptions, startup operations, descriptions of the operation and capability of the system and application software, and a key control plan. Training manuals shall be provided that identify the agenda, and defined objectives and detailed descriptions of the subject matter for each lesson.

Table 5-2

Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Electronic Entry Control Systems	16752/3.6	None	Operation and maintenance manuals shall include, but not be limited to, a hardware manual, software manual, operator's manual, and maintenance manual. The hardware manual shall describe all equipment furnished, including general descriptions and specifications, installation and checkout procedures, equipment electrical schematics and layout drawings, system schematics and layout drawings, alignment and calibration procedures, and interface definition. The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation, as well as definitions of terms and functions, use of system and applications software, procedures for initialization, startup and shutdown, alarm reports, reports generation, database data entry requirements, and descriptions of all communications protocols. The operator's manual shall fully explain all procedures and instructions for operation of the system, including computers and peripherals, system startup and shutdown procedures, use of system, command and applications software, recovery and restart procedure, graphic alarm presentation, use of report generator, data entry, operator commands, alarm messages and printing formats, and system access requirements. The maintenance manual shall describe maintenance for all equipment, including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.	Data shall be submitted including but not limited to system descriptions, startup operations, descriptions of the operation and capability of the system and application software, and a key control plan. Training manuals shall be provided that identify the agenda, and defined objectives and detailed descriptions of the subject matter for each lesson.

Table 5-2

Pentagon Heating and Refrigeration Plant
Summary of Training Support Documents Required by Specification

System/ Component	Section/ Paragraph	Operating Instructions	Operation and Maintenance Manuals	Other Documents
Plant Paging System	16770/3.4	None	Operation and maintenance manuals shall outline the step-by-step procedures required for system startup, operation and shutdown. Instructions shall include equipment layout and schematics of simplified wiring and control diagrams of the system as installed. A brief description of all equipment and their basic operating features shall be included. General maintenance instructions shall be furnished which list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Instructions shall include equipment layout and schematics and simplified wiring and control diagrams of the system.	None
Fire Detection and Alarm System	16721/3.8	None	Operation and maintenance manuals shall outline the step-by-step procedures required for system startup, operation and shutdown. Brief descriptions of all equipment and their basic operating features shall be included. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Manuals shall include conduit layout, equipment layout, and simplified wiring and control diagrams of the system as installed. Operation and maintenance manuals shall be approved prior to the field training course.	None

Table 5-3.
Outline of Training Program for NHRP

Subject	Content	Personnel	Schedule (1995)	Training (hours)	Performed by	Requirements in construction spec.
General arrangement ·Physical layout ·Major equipment ·Controls overview ·Cranes, elevators ·Fire protection ·Security	Plant description	All	Staggered, Sept. - Dec.	Classroom (4)	Bell-BCI	None
	Plant walkdown	All	Staggered, Sept. - Dec.	Plant (4)	Bell-BCI	
Steam generation system ·Boilers ·Economizers ·Feedwater reg. valve ·Forced draft fans ·Burners ·Flame safety equip. and controls ·Continuous blowdown equip.	System description	All except administrative staff	Oct. - Nov.	Classroom (2)	Bell-BCI	Field training course to be conducted for the maintenance and operating staff.
	System walkdown	All except administrative staff	Oct. - Nov.	Plant (2)		
	Start-up, operation, control	PM, OMM, SF, CO, GF, RM, EL, EICM	Nov. - Dec.	Plant (16)	Boiler and burner supplier, controls system supplier	
	Maintenance	SF, GF, RM, EL, EICM	Nov. - Dec.	Plant (16)		
Condensate-feedwater system ·Condensate and lift pumps ·Deaerators and feedwater pumps ·Chemical feed system ·Water softening and condensate polishing equipment Fuel oil transfer system pumps and strainers	System description	All except administrative staff	Oct. - Nov.	Classroom (2)	Bell-BCI	Field training course to be conducted for the maintenance and operating staff.
	System walkdown	All except administrative staff	Oct. - Nov.	Plant (2)		
	Start-up, operation, control	PM, OMM, SF, CO, GF, RM, EL, EICM	Nov. - Dec.	Plant (16)	Bell-BCI, eulpment suppliers	
	Maintenance	SF, GF, RM, EL, EICM	Nov. - Dec.	Classroom (4) Plant (16)		

Personnel key
PM = Plant Manager; OMM = Operations and Maintenance Manager; CO = Control Operator; RM = Repair Mechanic; SF = Shift Foreman; EL = Electrician; GF = General Foreman; and EICM = Electronics Industrial Controls Mechanic.

Training terms:
Classroom = structured study in classroom led by an instructor.
System walkdown = training on specific tasks using a checklist indicating critical evolutions and required actions; form of job performance measure.
Plant = operation or repair of equipment under the guidance of a qualified person.

*Training hours in construction specification appear much greater than needed based on subject areas; this should be reevaluated when O&M manuals are

Table 5-3.
Outline of Training Program for NHRP

Subject	Content	Personnel	Schedule (1995)	Training (hours)	Performed by	Requirements in construction spec.
Condenser water system ·Sluice gates ·Traveling screens ·Screen wash pumps (centrifugal) ·Circulating water pumps (vert. turbine)	System description	All except administrative staff	Sept. - Oct.	Classroom (2)	Bell-BCI	On-site instruction in the operation and maintenance of sluice gates and actuators. Training on centrifugal pumps – 8 hours. Training on vertical turbine pumps – 8 hours.
	System walkdown	All except administrative staff	Sept. - Oct.	Plant (2)		
	Start-up, operation, control	PM, OMM, SF, CO, GF, RM, EL, EICM	Sept. - Oct.	Plant (8)	Bell-BCI, equipment suppliers	
	Maintenance	SF, GF, RM, EL, EICM	Sept. (prior to performance test)	Classroom (4) Plant (4)		
Chiller system ·Primary compressor ·Speed increaser ·Primary motor ·Cooler ·Intercooler ·Condenser ·Unit control panel	System description	All except administrative staff	Sept. - Oct.	Classroom (2)	Bell-BCI	Chiller and chiller controls operator and maintenance training. UCP hardware and software training – 16 hours. Advanced operator training – 16 hours. Maintenance training – 8 hours.
	System walkdown	All except administrative staff	Sept. - Oct.	Plant (2)		
	Start-up, operation, control	PM, OMM, SF, CO, GF, RM, EL, EICM	Sept. - Oct. (during performance and endurance test)	Classroom (8) Plant (24)	Bell-BCI, equipment suppliers	
	Maintenance	SF, GF, RM, EL, EICM	Dec. (after completion of endurance test)	Classroom (4) Plant (4)		

Table 5-3.
Outline of Training Program for NHRP

Subject	Content	Personnel	Schedule (1995)	Training (hours)	Performed by	Requirements in construction spec.
Chilled water distribution system ·Chilled water distribution pumps ·Chiller loop circ. pumps ·Chemical feed system ·Centrifugal separator	System description	All except administrative staff	Sept. - Oct.	Classroom (2)	Bell-BCI	Field training to be provided for the chemical feed system for operating and maintenance personnel. Training on centrifugal pumps – 8 hours.
	System walkdown	All except administrative staff	Sept. - Oct.	Plant (2)		
	Start-up, operation, control	PM, OMM, SF, CO, GF, RM, EL, EICM	Sept. - Oct.	Plant (4)	Bell-BCI, equipment suppliers	
	Maintenance	SF, GF, RM, EL, EICM	Sept. (prior to performance test)	Classroom (2) Plant (2)		
Central distributed control system	System description	All except administrative staff	Sept.	Classroom (2) Plant (2)	Bell-BCI, system designers	Operators training I – 40 hours. Operators training II – 40 hours. Operators training III – 16 hours. Operators training IV – 24 hours.
	Operation	PM, OMM, SF, CO, EICM, computer systems specialist	June - Sept.	Classroom (20) Plant (20)		
			Aug. - Sept.	Plant (40)		
			Sept. - Dec.	Plant (16)		
	Simulator training	PM, OMM, SF, CO, GF, computer systems specialist	June - Dec.	Periodically (to be determined)	System designers and subsequently self-training	Simulator will need to be procured and arrangements made for training.
	Maintenance	EICM, computer systems specialist	June - Dec.	Periodically	System designers	Instrument installation – 8 hours. Software maintenance – 40 hours. (Note that arrangements need to be made to provide for the suggested June-Dec.training.)

Table 5-3.
Outline of Training Program for NHRP

Subject	Content	Personnel	Schedule (1995)	Training (hours)	Performed by	Requirements in construction spec.
Electrical systems ·Station power transformers ·Secondary unit sub. transformer ·Switchgear ·Station battery system ·5-kV MCCs ·480-V MCCs ·Load centers	System description	All except administrative staff	Sept. - Oct.	Classroom (2)	Bell-BCI	Station power transformers – 16 hours . Training on secondary unit substation transformer. Training on switchgear, station battery system, 5-kV MCCs, 480-V MCCs, load centers – two 8-hour sessions.
	System walkdown	All except administrative staff	Sept. - Oct.	Plant (2)		
	Start-up, operation, control	PM, OMM, SF, CO, GF, RM, EL, EICM	Sept. - Oct.	Classroom (4) Plant (12)	Bell-BCI, equipment suppliers	
	Maintenance	GF, SF, EL, EICM	Sept. - Dec.	Classroom (4) Plant (12)		
Compressed air equipment	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (4)	Bell-BCI, equipment suppliers	Instruction in the start-up, operation, and maintenance of equipment.
	Maintenance	GF, RM, EL				
Sewage and sump pumps (plant)	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (8)	Bell-BCI, equipment suppliers	Instruction in the start-up, operation and maintenance of equipment – 8 hours.
	Maintenance	GF, RM, EL				
Forced hot water heating systems using steam heat exchangers	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (16)*	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals – 16 hours.
	Maintenance	GF, RM, EL				
Central refrigerated air conditioning system	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (8)	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals – 8 hours.
	Maintenance	GF, RM, EL, EICM				
Air supply and distribution system (for air conditioning system)	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (40)*	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals – 40 hours.
	Maintenance	GF, RM, EL, EICM				
Ventilation and exhaust systems	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (24)*	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals – 24 hours.
	Maintenance	GF, RM, EL, EICM				

Table 5-3.
Outline of Training Program for NHRP

Subject	Content	Personnel	Schedule (1995)	Training (hours)	Performed by	Requirements in construction spec.
Heating, ventilating and air conditioning control systems	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (32)*	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals – 32 hours.
	Maintenance	GF, RM, EL, EICM				
Hydraulic elevators	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (8)	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals – 8 hours.
	Maintenance	GF, RM, EL				
Electric overhead traveling cranes (top running and overhung, 30 ton max.	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (8)	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals – 8 hours.
	Maintenance	GF, RM, EL				
Monorails and hoists	Start-up, operation	SF, CO, GF, RM, EL	Sept. - Dec.	Plant (8)	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals.
	Maintenance	GF, RM, EL				
Intrusion detection systems	Start-up, operation	PM, OMM, SF, CO, GF, RM, EL,EICM **	Sept. - Dec.	Plant (28)*	Bell-BCI, equipment suppliers	Operators training I – 16 hours . Operators training II – 8 hours. Operators training III – 4 hours. Maintenance training – 24 hours.
	Maintenance	GF, RM, EL, EICM	Sept. - Dec.	Plant (24)*		
Electronic entry control systems	Start-up, operation	PM, OMM, SF, CO, GF, RM, EL, EICM **	Sept. - Dec.	Plant (52)*	Bell-BCI, equipment suppliers	Operators training I – 24 hours . Operators training II – 16 hours. Operators training III – 12 hours. Maintenance training – 40 hours.
	Maintenance	GF, RM, EL, EICM	Sept. - Dec.	Plant (40)*		
Plant paging system	Start-up, operation	PM, OMM, SF, CO, GF, RM, EL, EICM **	Sept. - Dec.	Plant (8)	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals – 8 hours.
	Maintenance	GF, RM, EL, EICM				
Fire detection and alarm system	Start-up, operation	PM, OMM, SF, CO, GF, RM, EL, EICM **	Sept. - Dec.	Plant (24)*	Bell-BCI, equipment suppliers	Training course covering all items in the O&M manuals – 24 hours.
	Maintenance	GF, RM, EL, EICM				

Table 5-4.
Summary of Training Hours by Position

Position	Total hours
Plant Manager	260
Operations and Maintenance Manager	374
Computer Systems Specialist	92
Shift Foreman	414
Control Operator	338
Electronics Industrial Controls Mechanic	477
General Foreman	556
Repair Mechanic	500
Pipefitter-Welder	36
Electrician	516
Administrative staff	8

APPENDIX A

Pentagon Utilities Plant Systems and Controls

Pentagon Utilities Plant Systems and Controls

This appendix describes the general features of the existing Pentagon Utilities Plant (PUP). Annex 1 contains a more detailed description of the plant systems, and Annex 2 describes the PUP system controls.

General Plant Description

The PUP provides heating steam to the Pentagon, Navy Annex [Federal Office Building (FOB) 2], and Marine Corps Headquarters (Henderson Hall) in the Arlington, Virginia, area. The steam is distributed at 125 psig through tunnel basements and underground piping. Steam pressure is reduced at the individual buildings, and condensate is returned to the plant. The condensate lines are equipped with valves, strainers, and steam traps. This plant also provides chilled water for air conditioning to the Pentagon and FOB 2.

The facility is located east-southeast of the Pentagon adjacent to Interstate 395. Cooling water intake is from the Potomac River via the lagoon adjacent to Columbia Island. Makeup water is from the D.C. and Arlington County water systems. Sewage is discharged via the plant sewage pumping system into the Arlington County sewage treatment system.

Boilers

The PUP has one permanently installed boiler (Boiler No. 1) and three rental boilers. At one time, five permanently installed boilers were in place, but four have since been demolished. Boiler No. 1 has a capacity of 125,000 pounds per hour of steam, and the rental boilers each have a capacity of 60,000 pounds per hour. The rental boilers are mounted on truck trailer beds. Steam conditions are 125 psig and 353°F. All boilers are equipped to burn natural gas or fuel oil. Annual consumption is about 80 percent natural gas and 20 percent fuel oil in the summer and the reverse (20 percent natural gas, 80 percent fuel oil) in the winter. Current practice is to burn a low sulfur (less than 0.2 percent) grade No. 2 oil.

Fuel

Fuel oil is delivered by truck and pumped, via the appropriate unloading station, to fuel oil storage tanks.

The original tanks had a capacity of 524,000 gallons, but these were recently dismantled. The capacity of the temporary storage tank is 60,000 gallons. Consumption during the recent cold spell in 1994 was about 22,000 gallons per day, and emergency shipments by tanker trucks (7,000 gallons per truck) were necessary. Large capacity tanks are planned for the new facility. If these are not installed by next winter, additional temporary storage will be sought.

Natural gas is fed to the plant by pipelines from Washington Gas Light Company. Gas is provided on an interruptible basis, i.e., gas supply can be cut off during periods of high demand.

Forced Draft Fans

Boiler No. 1 has a forced draft fan and is a positive pressure furnace. The fan is motor-driven. The forced draft fans for the rental boilers are located on their individual trailer beds.

Feedwater System

The feed pumps have capacities of 600 to 800 gallons per minute. The feedwater system receives makeup from the D.C. and Arlington County water systems. City water is supplied from one of two city water mains and is piped directly through zeolite softeners to a surge storage tank on the upper level of the boiler house. Condensate returning from the heating system is piped to a receiving tank. From the receiving tank, the condensate is pumped by one of the two pumps through condensate polishers before being sent and stored in the surge tank. At the surge tank, the condensate and makeup water mix and flow by gravity to the two deaerators below. In the deaerators, the feedwater is heated and deaerated then flows to one of the three boiler feed pumps on the first floor.

Combustion Control

Boiler No. 1 is controlled by a pneumatically operated combustion control system manufactured by Coen Controls. The rental boilers use digital controls made by Bailey Meter Company and are serviced by the leasing contractor.

Steam System

The majority of the 125 psig steam produced is used by the Pentagon and Federal buildings that the plant serves. The steam, referred to as high pressure steam, is also used inside the plant to power the turbine-driven feedwater pumps. The steam leaving these turbines is used as low pressure steam in the deaerators to heat and deaerate feedwater and to supply the plant heating,

ventilation, and air conditioning system. The high pressure steam also can be piped through a pressure reducer (6 psig) and used to heat fuel oil at the fuel oil burner pumps.

Refrigeration Plant

The PUP contains four of its original eight electrically driven centrifugal chillers and seven rental chillers serving a common system. The chilled water pumps deliver chilled water to each of the buildings on the system for air conditioning. The original chillers are rated at 5,000 tons each and the rental chillers at 1,000 tons each. The combined pumping capacity of the chilled water pumps is approximately 51,500 gallons per minute. All the chillers use the same basic cycle to chill the water. Refrigerant Type 500 (freon) is used in the PUP chillers, and Type 11 is used in the rental units. The refrigerant flows in the closed loop. Absorbing heat from the chilled water, the refrigerant evaporates and travels through the compressor to the condenser where it gives up the energy it absorbed from the chilled water to the condenser water. The condenser water is pumped from the Columbia Island lagoon next to the Potomac River through the condensers and is returned to Roaches Run and to the Potomac River. There are six condenser water pumps, one traveling screen, two strainers, and one trash rack.

The design inlet temperature for the chillers is 88°F. Plant personnel reported that the temperature has been as high as 91°F during the summer. This higher-than-design temperature necessitates a reduction in cooling capacity.

Electrical System

The plant's electrical distribution system is supplied by three 13.2-kV feeders via 230-kV to 69-kV transformers at the Virginia Power Company substation located adjacent to PUP. Two of the three feeders are reduced in voltage to feed the 4,160-V system, and one is reduced in voltage to feed the 2,300-V systems. Power for the 480-V, three-phase system and the 120/180-V, one-phase system is provided by transformers located throughout the facility. Also, 13.2-kV is supplied to the Pentagon where it is reduced to 480 V.

Power from three 69-kV feeders is available from the Potomac Electric Power Company (Pepco) on a standby basis.[1] In addition, several local emergency power sources are located around the Pentagon and other buildings.

[1] Originally, Pepco provided electricity to the PUP but transferred its power supply to Virginia Power several years ago.

Main Control Panels

The plant's systems and equipment are controlled and monitored locally from various control panels and instruments located throughout the plant. The following control panels are installed in the plant:

- *Main control panel.* This panel is installed in a central control room located on the first floor. It includes traditional hard-wired controls, indicators, and recorders for Boiler No. 1 to allow partial monitoring and control of the boiler and support system. These include the plant master control that sends a signal to the boiler master to increase or decrease the firing rate of the boiler as determined by the main header pressure. The boiler master, in turn, sends a signal to the fuel and air control systems to regulate the firing rate. During normal operation, this is done automatically by a combination of pneumatic and electric controls. During start-up, shutdown, and abnormal conditions, the system is put in manual to allow the operator to control the boiler firing. Most other plant control functions are performed by a combination of local manual controls and auto/manual controllers throughout the plant. No significant microprocessor or digital controls are used for control or monitoring of Boiler No. 1. Local controls for the rental boilers are located at the front of their respective truck beds. These include a digital master control panel and local controls and indicators on each of the three boilers. Plant personnel operate these rental boiler controls, but contract personnel perform the maintenance, troubleshooting, and calibration.

- *Refrigeration control panel.* This control panel is located on the floor of the refrigerant plant and is used for controlling and monitoring the operation of the original chillers. Recently added digital control panels allow semi-automated operation of many chiller functions, including start-up. Digital controls for the rental chillers are located on their respective skids. Contract personnel maintain these rental units and their controls.

Sewage Pumping Station

Responsibilities of PUP include the sewage pumping station that handles effluent from the Pentagon, the heating/refrigeration plant, and Arlington Cemetery. The sewage pumping station is located at the north end of the North Parking Area, about a 10-minute drive from the PUP facility. The sewage pumping station includes a comminutor, piping, valves, and pumps that are checked every watch by PUP shift personnel. The sewage is pumped from the holding area to the Arlington County Sewage Treatment System via Arlington sewage lines.

APPENDIX A ANNEX 1

Pentagon Utilities Plant Systems Description

Pentagon Utilities Plant Systems Description

General Arrangement

The Pentagon Utilities Plant (PUP) has three basic sections: the boiler plant, the refrigeration plant, and the exterior, which is used for fuel storage, electrical switchhouses, and other systems. Figures A1-1, A1-2, and A1-3 show the general arrangement of the plant. The plant's major systems, and their major components, are listed below:

- Feedwater-condensate systems, including two deaerating heaters
- Sewage system, including three sewage pumps, sewage comminutor, two sump pumps, sewage ejector, and two sewage collecting tanks
- Combustion air and flue gas system, with six air compressors and associated air receivers, aftercoolers, and dryers
- Steam generation systems, including one permanently installed plant steam boiler — with forced draft fans, soot blowing systems, blowdown systems, and fuel firing systems — and three rental boilers
- Steam distribution systems, including high pressure steam piping, isolation valves, expansion joints, and supports
- Fuel systems, including three fuel oil unloading pumps and three fuel oil burner pumps
- Refrigeration systems, including four 5,000-ton chillers — with chiller condensers and chilled water coolers — and seven rental chillers, six condenser water pumps, and six chilled water pumps
- Electrical systems, including the following components:
  - Five 1,200 amp, 13.2-kV air-cooled circuit breakers
  - Twelve 1,200 amp, 13.2-kV bus ties
  - Three 13,200/2,500-V step-down transformers
  - Four 13,200/4,160/2,400-V step-down transformers
  - Five 2,300/480/277-V step-down transformers

- Auxiliary systems.

The principal features of the PUP systems are discussed below.

FEEDWATER-CONDENSATE SYSTEMS

The feedwater-condensate systems include the city water, treated water, boiler feedwater, and boiler chemistry control systems.

City Water System

The function of the city water system is to provide water to the various plant operating systems (see Figure A1-4). Three inlet lines, two from the District of Columbia and one from Arlington County, feed the PUP supply header, which, in turn, supplies water to the condensate system (makeup water), locker rooms, rest room wash, drinking fountains, hot water tanks, and plant wash outlets. City water also supplies water, in the event of emergency conditions, to the fire systems, the surge tank, the condensate polishers, and the zeolite softeners for prefilling the entire treated water system for a plant cold start. Also, city water is used as makeup for chilled water plant. This system is located in the basement of the chiller plant.

Treated Water System

The function of the treated water system is to treat and filter raw city water to produce softened feedwater used in steam generation. The treated feedwater is stored prior to delivery to the feed pumps.

The treated water system consists of two deaerating heaters and two zeolite softeners that deaerate and remove scale-producing compounds from the water (see Figure A1-5). The water from the zeolite softeners passes to the surge tank and into the deaerators to provide feedwater suction

The treated water system also includes several subsystems that support its operation:

- Zeolite softener regeneration subsystem, which is used to regenerate the zeolite bed
- Brine subsystem, which provides the brine solution for generating the softeners
- Chemical feed subsystem, which is provided with treated water to dilute the chemicals prior to injection into the boilers

- Effluent sample subsystems, which enable the operator to determine if the zeolite softeners are functioning properly
- Low pressure steam subsystem, which provides steam for raising the temperatures and deaerating the feedwater in the deaerators
- City water subsystem, which provides water to the treated water system to fulfill plant steam generating requirements.

Boiler Feedwater System

The boiler feedwater system (shown in Figure A1-6) consists of two deaerator storage tanks that store the feedwater and three feedwater pumps that can transfer the feedwater to the boilers. The feedwater pumps are provided with secondary subsystems that allow feedwater to be recirculated back to the surge tank if necessary to maintain a proper suction head.

Boiler Chemistry Control System

The boiler chemistry control system consists of a chemical station that supplies the feedwater system with chemicals and a continuous blowdown system that samples, measures, and reduces the contamination levels in the boiler water (see Figure A1-7).

SEWAGE SYSTEM

The plant sewage system routes wastewater to the Arlington city sewers from the PUP, the Pentagon (services and sanitary services), the Arlington Cemetery Visitors Center, and the incinerator. The system consists of storm water, sanitary water, and plant process wastewater and incinerator quench water subsystems (see Figure A1-8). The wastewater system is equipped with intercepting traps that prevent debris and sewage from backing up into the lines. The sanitary waste and plant process waste subsystems also are equipped with traps that prevent sewer gases from backing into the lines. Also, the plant's sewage system handles wastewater and ash pit water from the incinerator building, located west of the plant.

The ground water system is directly connected to the city storm sewers that empty into the Potomac River. Sanitary and process wastewater from the plant and incinerator enters the sewage pumping station and then is pumped into the Arlington sanitary sewage system to be treated at its sewage treatment plant.

Combustion Air and Flue Gas System

The function of the combustion air system is to supply air to the boiler furnace to ensure the complete combustion of the fuel oil supplied to the furnace. The function of the flue gas system is to remove the gases resulting from the combustion of fuel in the boiler.

The combustion air and flue gas system for Boiler No. 1 consists of a forced draft fan that supplies combustion air into the furnace (see Figure A1-9). The flue gas discharges into the atmosphere through the stack. The air and gas systems for the three rental boilers include individual forced draft fans mounted on the truck beds and exhaust stacks mounted at the furnace outlets.

Steam Generation Systems

The steam generation systems include Boiler No. 1 with its soot blowing and blowdown systems and three rental boilers.

Boiler No. 1

Boiler No. 1 has a design capacity of 125,000 pounds per hour of saturated steam at 125 psig and 353°F. The steam generation system consists of a steam drum, which allows for the distribution and separation of incoming feedwater and outgoing steam, and a water drum that holds and supplies boiler water to the side, front, and rear waterwall tubes and to the steam generating tubes (see Figure A1-10). The steam drum is equipped with outlet connections that allow for venting, overpressure protection (safety valves), steam discharge, and blowdown.

The steam generation system also includes several subsystems that support plant operation:

- High pressure steam subsystem that provides high pressure steam for fuel atomization
- High pressure steam subsystem that provides steam for feedwater turbines
- Low pressure steam subsystem for feedwater heating and space heating.

Soot Blowing System — Boiler No. 1

The soot blowing system consists of two air-puff-type soot blowers on Boiler No. 1; both are in the generating tube bank (see Figure A1-11). These blowers are controlled through a control panel to keep the boiler fireside surfaces

clean. The soot blowers are utilized as often as necessary, and according to boiler operating conditions, to maintain efficient steam generation.

Blowdown System – Boiler No. 1

The boiler blowdown system removes dissolved and undissolved solids from water in the boiler steam drum, mud drum, and water wall headers in order to control boiler water chemistry. The blowdown system (surface and bottom blowdown), illustrated in Figure A1-12, contains blowdown control valves that regulate the flow of boiler water into the blowdown system, a blowdown heat exchanger to recover heat and steam from the continuous boiler blowdown water, and a blowdown separator to separate and dispose of flash steam and hot blowdown water.

The boiler blowdown system also includes several subsystems:

- City water subsystem, which provides water to the blowdown separator to cool bottom blowdown and the continuous blowdown from the blowdown heat exchangers
- Plant sewage subsystem, which pumps waste blowdown and condensate to the city sanitary sewer system
- Automatic conductivity control subsystem.

Rental Boilers

The three rental boilers are rated at 60,000 pounds per hour each at 125 psig and 353°F. (Plant personnel indicated that the maximum output is limited to about 40,000 pounds per hour for reliable operation.) The rental boilers receive feedwater from the main header, as shown on Figure A1-6, and the outlet steam is fed to the common steam header. Digital combustion controls, manufactured by Bailey Meter Company, are provided for each boiler. Start-up and shutdown are semiautomatic, requiring only push-button operation and observations by the operator. Blowdown from the rental boilers is piped to the blowdown system serving Boiler No. 1.

Steam Distribution Systems

The steam systems include the high and low pressure steam systems and the condensate return system.

High Pressure Steam System

The function of the high pressure steam system is to route the steam generated in the boilers through a steam distribution system to the Pentagon, Federal Office Building 2 (Navy Annex), and Henderson Hall where the steam is used for space heating, cafeteria use, and cleaning. In addition, the system also provides high pressure steam throughout the PUP for operating auxiliary plant equipment, such as pump turbines and soot blowers, and for heating feedwater and fuel oil (see Figure A1-13).

High pressure steam is supplied through 10-inch transfer lines to a 20-inch main supply header loop inside the plant. The main supply header loop is fed from all boilers and is equipped with isolation valves. Connections off the main supply header loop consist of 6- and 8-inch auxiliary plant headers, and a 16-inch header through the tunnel to the steam distribution system. The steam distribution system supplies high pressure steam for heating the Pentagon and other government buildings. Once the steam is condensed, the condensate is returned through an 8-inch condensate line.

The high pressure steam system consists of several subsystems that support its operation:

- Plant main steam header, which loops around the plant and may be divided at several places, if necessary, in emergencies
- Auxiliary metered steam header (from the main steam header), which supplies plant steam turbines and other plant steam requirements
- Condensate drain subsystem, which collects high pressure condensate and protects system piping and components from damaging the water hammer.

Low Pressure Steam System

The low pressure steam system supplies steam to the surge tank and deaerators for feedwater heating and to room air heaters for space heating. The low pressure steam system consists of a steam distribution pipeline system with isolation and control valves that regulate the flow of steam throughout the plant.

The low pressure system normally is supplied from the exhaust from the plant's feedwater turbines. A pressure-reducing valve is also provided to supply high pressure steam makeup for the low pressure steam system, if necessary. The low pressure steam system is illustrated in Figure A1-14.

Condensate Return System

The condensate return system consists of the high pressure condensate return and low pressure condensate return systems.

The high pressure condensate system consists of high pressure drains from the Pentagon steam supply piping and the plant high pressure steam piping. This high pressure condensate is returned directly into the deaerating storage tanks.

The low pressure condensate return system consists of low pressure drains from the plant low pressure steam system, condensate from the buildings and condensate from the heating, ventilation, and air conditioning (HVAC) system inside the plant. Low pressure condensate is pumped to the condensate polishers for chemical softening and then to the surge tank for storage (see Figure A1-15).

FUEL SYSTEMS

The fuel system includes the fuel oil handling and firing systems.

Fuel Oil Handling System

The fuel oil handling system consists of truck unloading stations for the delivery of fuel oil. The fuel oil unloading stations empty into the transfer tank. The fuel oil handling system is equipped with unloading pumps that transfer the delivered fuel from the transfer tank to the three fuel oil storage tanks. Fuel in the storage tanks is supplied to the fuel oil system for the boilers (see Figure A1-16).

Fuel Oil Firing System

The fuel oil firing system consists of storage tanks and burner pumps that route fuel oil to the burners from the oil storage tanks (see Figure A1-17). The fuel oil pumps are equipped with suction and discharge duplex strainers that remove debris carried through the lines. Heaters in the fuel oil lines heat the supply fuel oil to increase the efficiency of the atomizing process.

The fuel oil firing system also includes several subsystems:

- Natural gas ignition subsystem, which supplies gas to the boiler igniter system for main burner start-up
- Fuel oil atomizing subsystem, which is supplied with steam for fuel oil atomization and line purging
- Combustion air subsystem, which uses forced draft fans to supply combustion air to the boiler furnaces.

REFRIGERATION SYSTEMS

The refrigeration systems include the condenser water, chilled water, and chiller systems.

Condenser Water System

The condenser water system supplies water to the refrigeration plant chillers for removing heat contained in the refrigerant. The condenser water system consists of condensers that provide the means for the refrigerant heat removal. The condenser water source is the Potomac River via the lagoon adjoining Columbia Island. Water from the river enters the condenser water pit after passing through a bar screen, two sluice gates, and the traveling screen located at the lagoon. The system is equipped with six condenser pumps that route water from the condenser water supply pit through two automatic strainers to the condensers and back to the river (see Figure A1-18). The design temperature of the chillers is 89°F. However, temperatures in the lagoon have exceeded this design limit by a few degrees on some occasions (up to about 91°F).

Chilled Water System

The chilled water system routes chilled water to heat exchangers to condition and cool the air at the various buildings on the system. The chilled water system consists of a six pumps connected to a piping manifold that circulates water through the chiller evaporators and then to the various buildings in the system and back again to the pumps. This system is a closed loop system (see Figure A1-19). Isolation valves for each of the six chilled water pumps enable the operator to isolate each pump as needed.

The chilled water system also includes a makeup system that supplies city water to the system, when necessary, to maintain normal operating conditions. A chemical feed system provides for the injection of chemicals for corrosion control.

Chiller System

The chiller system removes the heat absorbed by the chilled water in the buildings in the system and transfers that heat to the condenser water. At one time, eight permanently installed chillers were in place at the utilities plant. Of these eight chillers (one of which was decommissioned many years ago), four chillers, rated at 5,000 tons each, remain in service. These are supplemented by seven rental chillers rated at 1,000 tons each.

The chiller system consists of a refrigerant compressor, condenser, and evaporator that permit the refrigerant to cool the warm chilled water passing

through the cooler. The chillers are equipped with a refrigerant pump system that allows removal and addition of refrigerant from the chillers (see Figure A1-20).

The chiller systems also include subsystems:

- Compressor oil subsystem, which provides lubrication and cooling of the compressor's journal and thrust bearings and serves as a shaft seal
- Air purge subsystem, which provides the means for removal of noncondensable gases from the chillers
- Refrigerant gas leak detection subsystem, which checks and notifies, through alarms, of refrigerant leaks at the pump-out receivers
- Pumpdown subsystem, including storage tanks.

ELECTRICAL SYSTEMS

The electrical systems consist of high and low voltage systems.

High Voltage System

The PUP high voltage system receives its power from three 13.2-kV Virginia Power Company feeders located in Switchhouse No. 1. The 13.2-kV switchgear in Switchhouse No. 1 feeds the 13.2-kV switchgear in Switchhouse No. 2, the 4,160-V transformers, and the Pentagon. Switchhouse No. 2 provides power to the refrigeration plant chiller units.

The 13.2-kV switchgear in Switchhouse No. 1 also feeds three 13,200/2,500-V station service transformers for use at the 2,300-V switchgear (see Figure A1-21). The 2,300-V switchgear supplies the lower voltage loads in the plant. All high voltage switchgears are controlled locally at the switchgears and are provided with emergency control power by a 125-V direct current (DC) battery system.

Low Voltage System (480/208/120 V)

The low voltage system receives power from the high voltage system and, after transforming it down to the required voltage, supplies all of the plant's lower voltage loads.

The low voltage system is used for lighting and controlling auxiliary electrical loads (see Figure A1-22). The loads supplied by the low voltage system are powered from switchboards, motor control centers, and power panels. All

voltage to these panels and boards must be transformed down from a higher value of supply voltage by means of various transformers rated at specific voltages.

Two DC voltage systems convert the low voltage system supply to DC to charge the battery banks used to switch (or operate) the high voltage system switchgears. The DC system offers an uninterrupted source of control voltage for the safe operation of the high voltage switchgear.

AUXILIARY SYSTEMS

Auxiliary plant systems include compressed and instrument air, plant services (including communications and HVAC), and fire protection.

Compressed Air System

The function of the compressed air system is to supply compressed air throughout the plant for operating pneumatic tools and components and for system control (instrument air) applications. The compressed air system consists of air compressors, air dryers, and storage receivers that maintain and supply compressed air for plant operation and for the Pentagon. Compressed air is supplied to air receivers from the air compressors and is then supplied to the service and instrument air systems to meet the plant demands (see Figure A1-23).

The compressed air system also includes a water cooling system that supports compressor operation and routes water through aftercoolers to cool the discharge air prior to distribution to the compressed air system and through compressor water jackets to remove the heat generated during the air compression process.

Plant Services Systems

The plant services systems provide support services required for daily plant operations. Plant services include a vacuum system for housekeeping services, a service elevator for transportation, a telephone/intercom system for plant communications, an HVAC system for climate control, and two overhead cranes in the refrigeration plant for moving large refrigeration equipment.

Fire Protection System

The fire protection system includes a foam fire system at the fuel oil unloading tank and a standpipe and water sprinkler system throughout the interior of the plant.

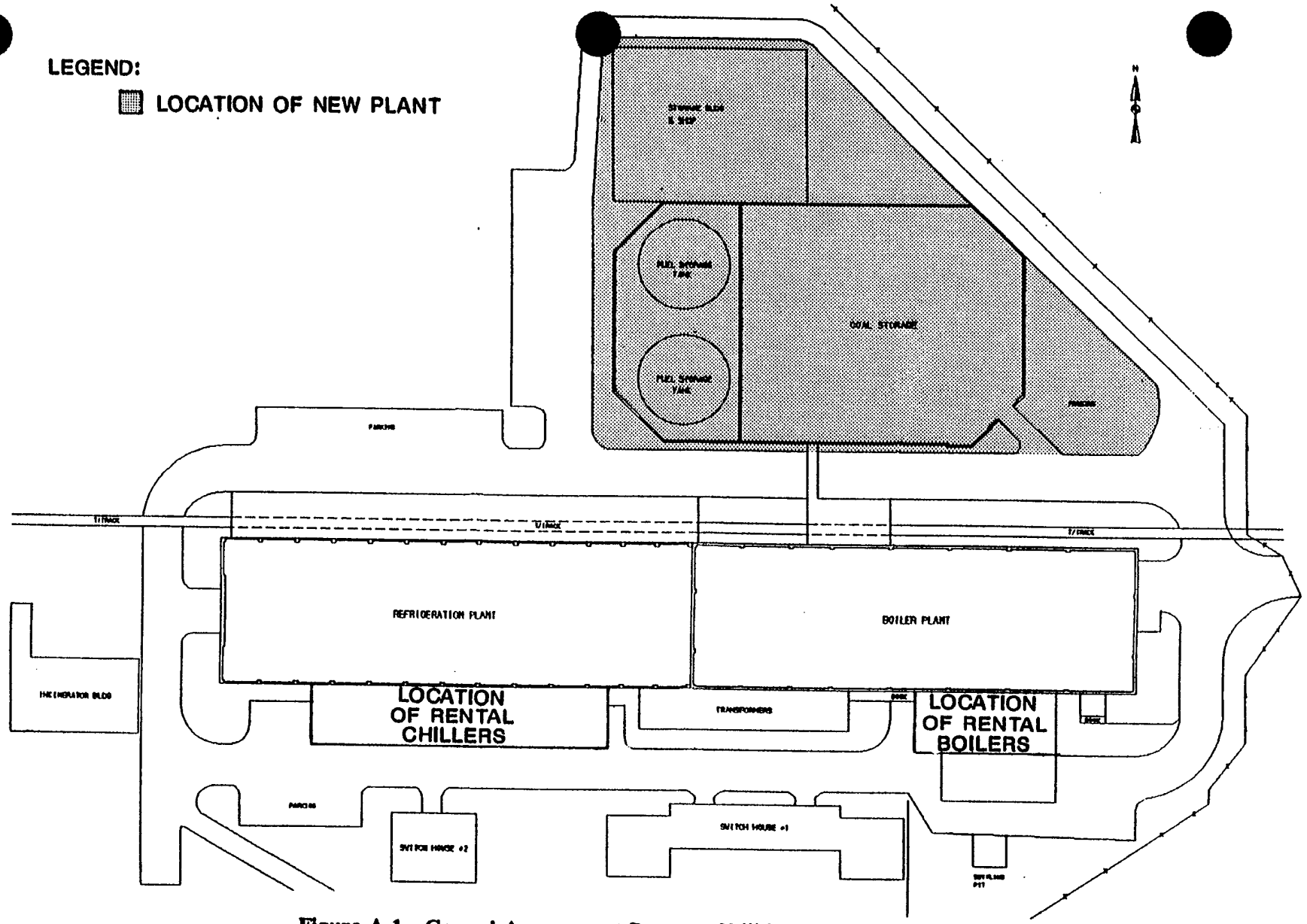

Figure A-1. General Arrangement Pentagon Utilities Plant - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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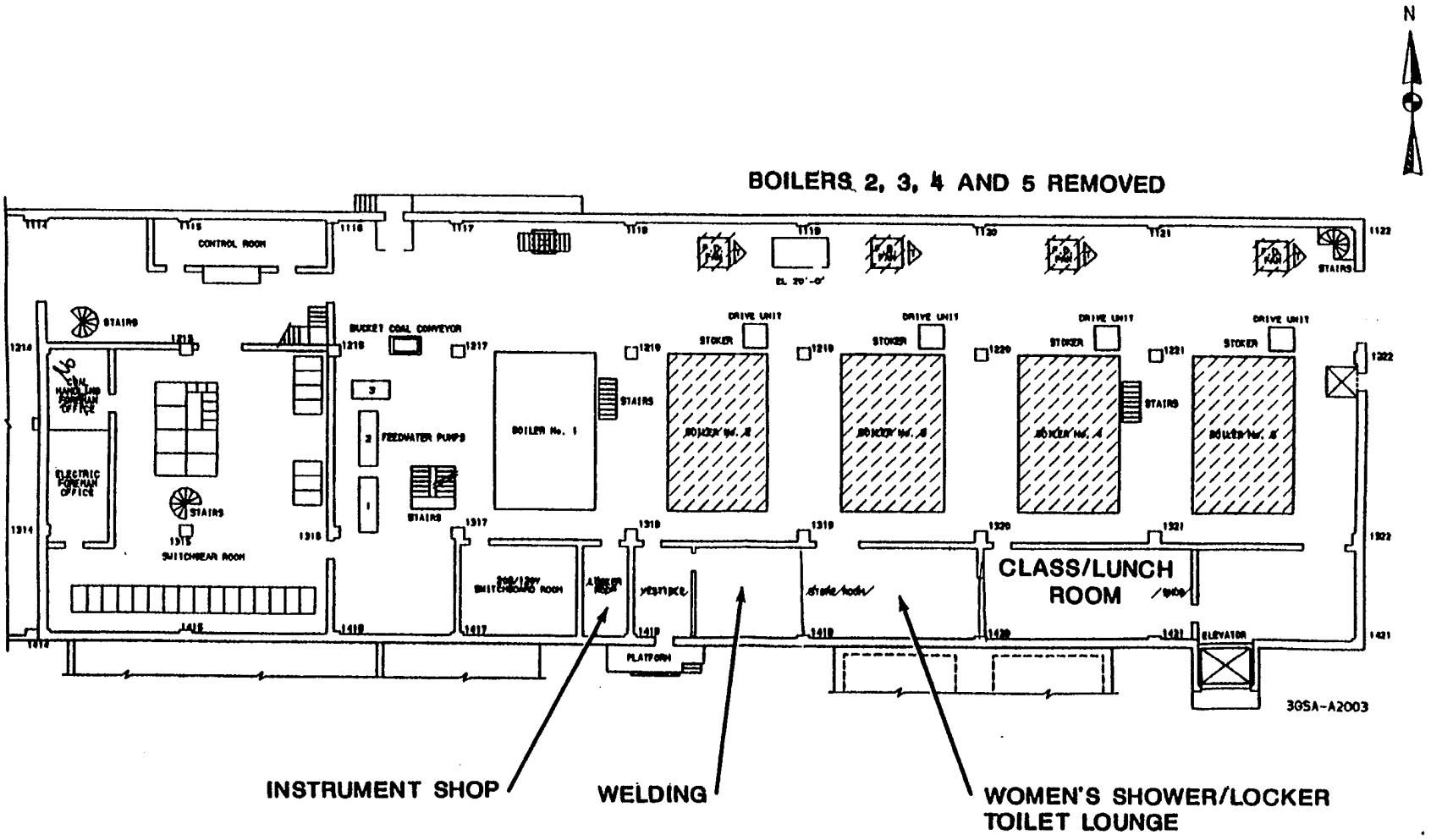

Figure A-2. Operating Floor Elevation 20'-0" Boiler Plant - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

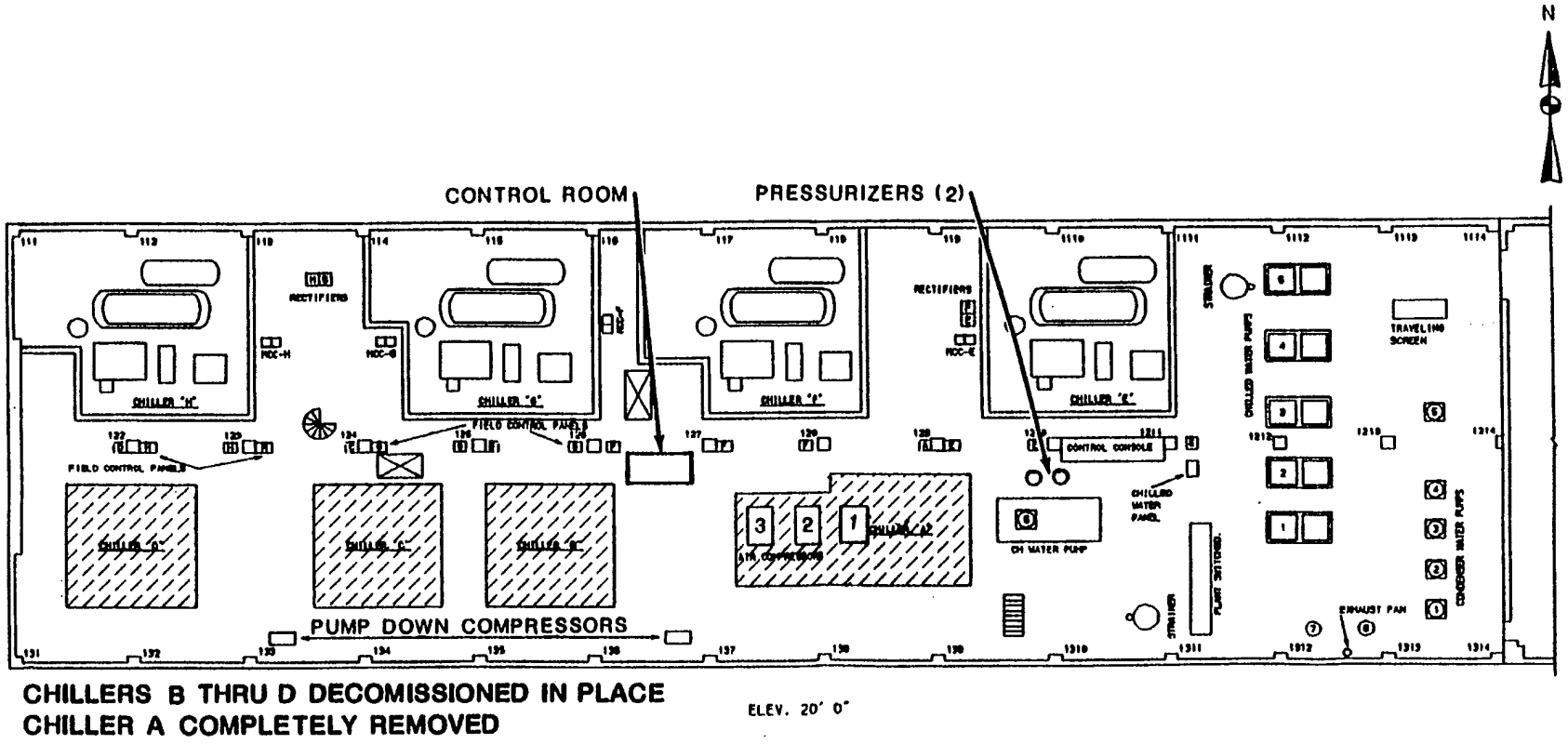

Figure A-3. Operating Floor Refrigeration Plant - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

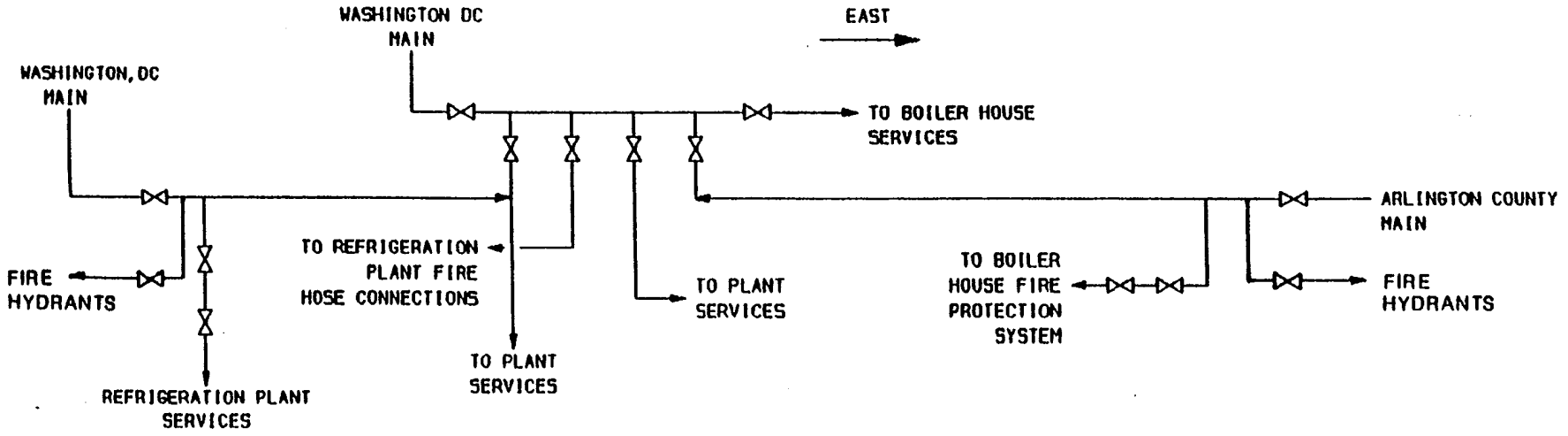

Figure A-4. City Water and Fire Hydrant System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

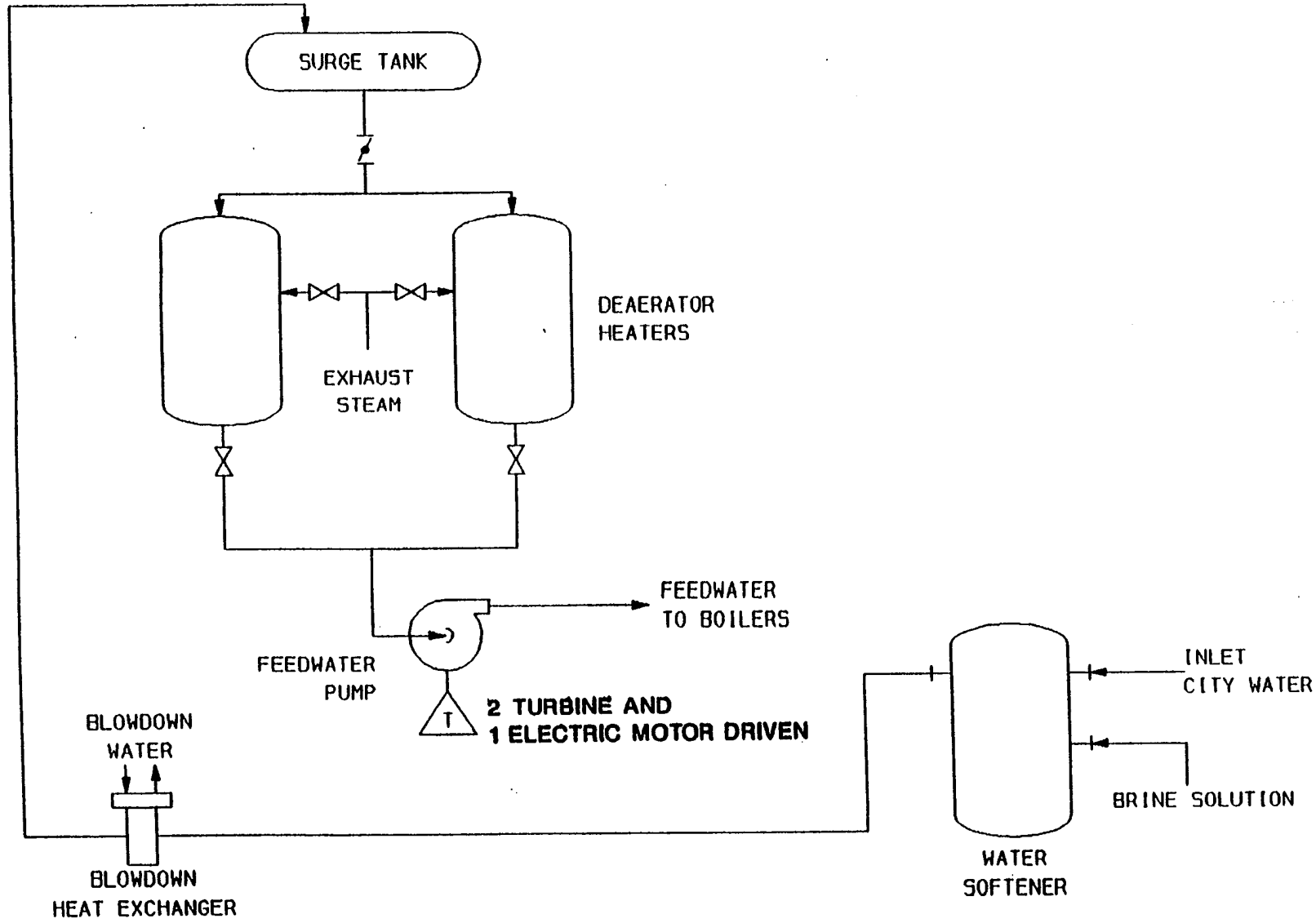

Figure A-5. Treated Feedwater System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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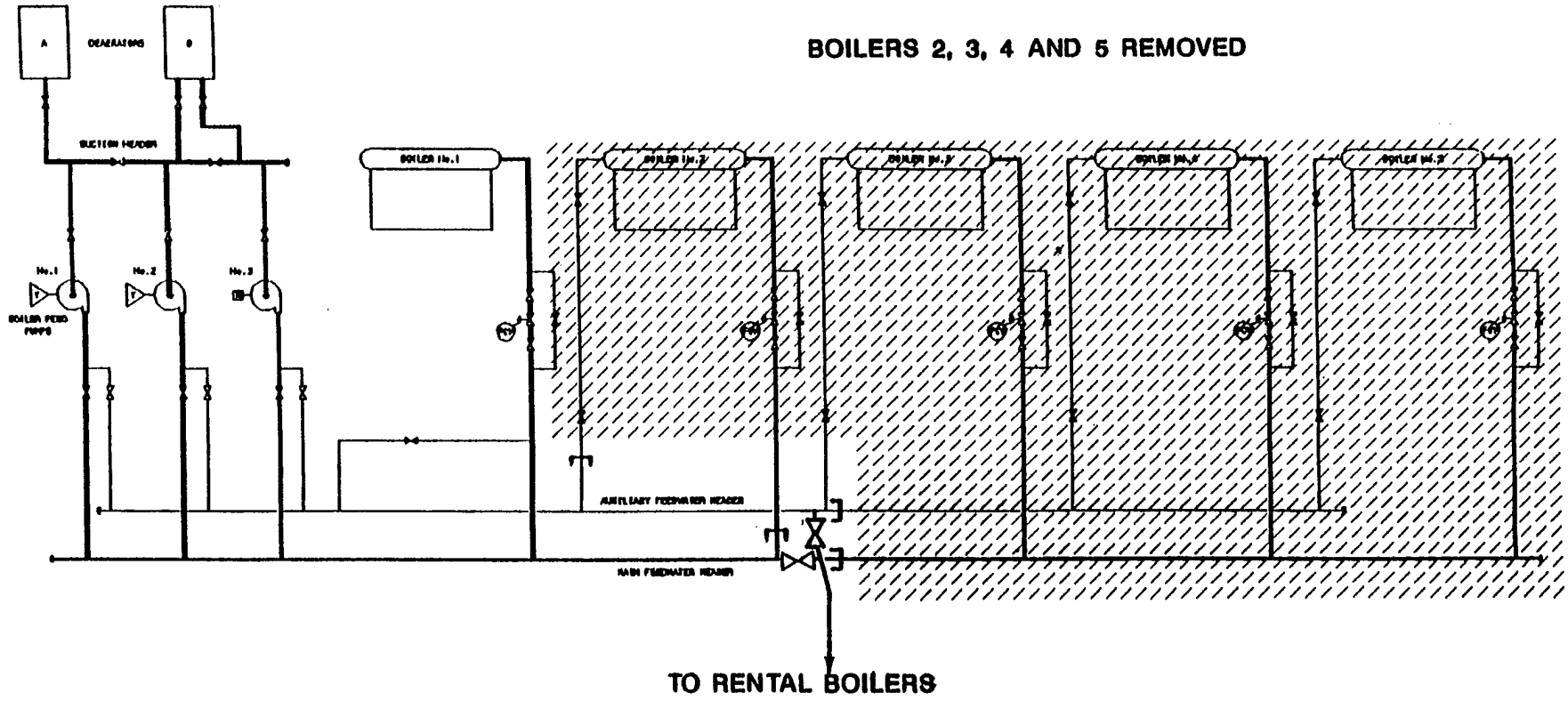

Figure A-6. Boiler Feedwater System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

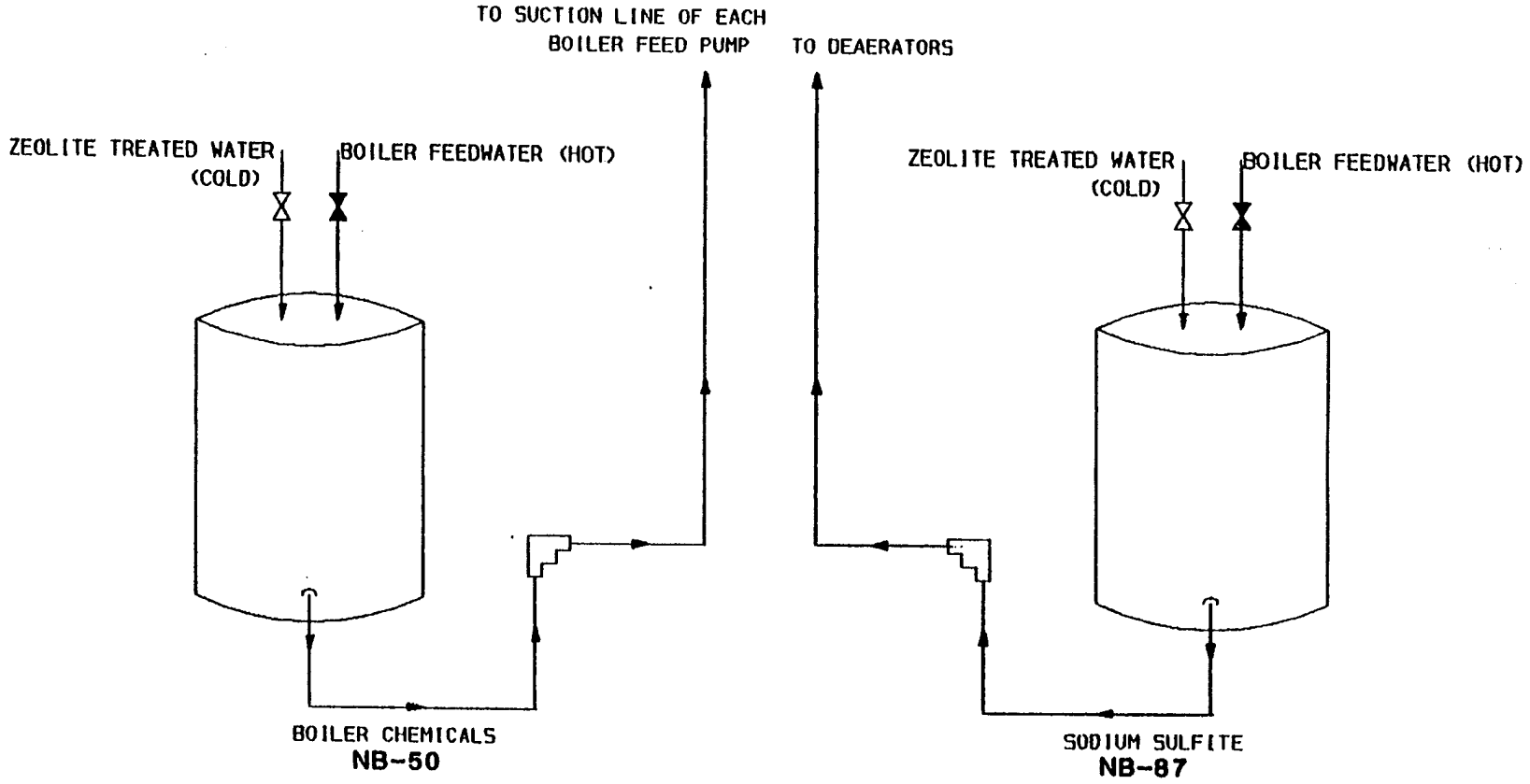

Figure A-7. Boiler Chemistry Control System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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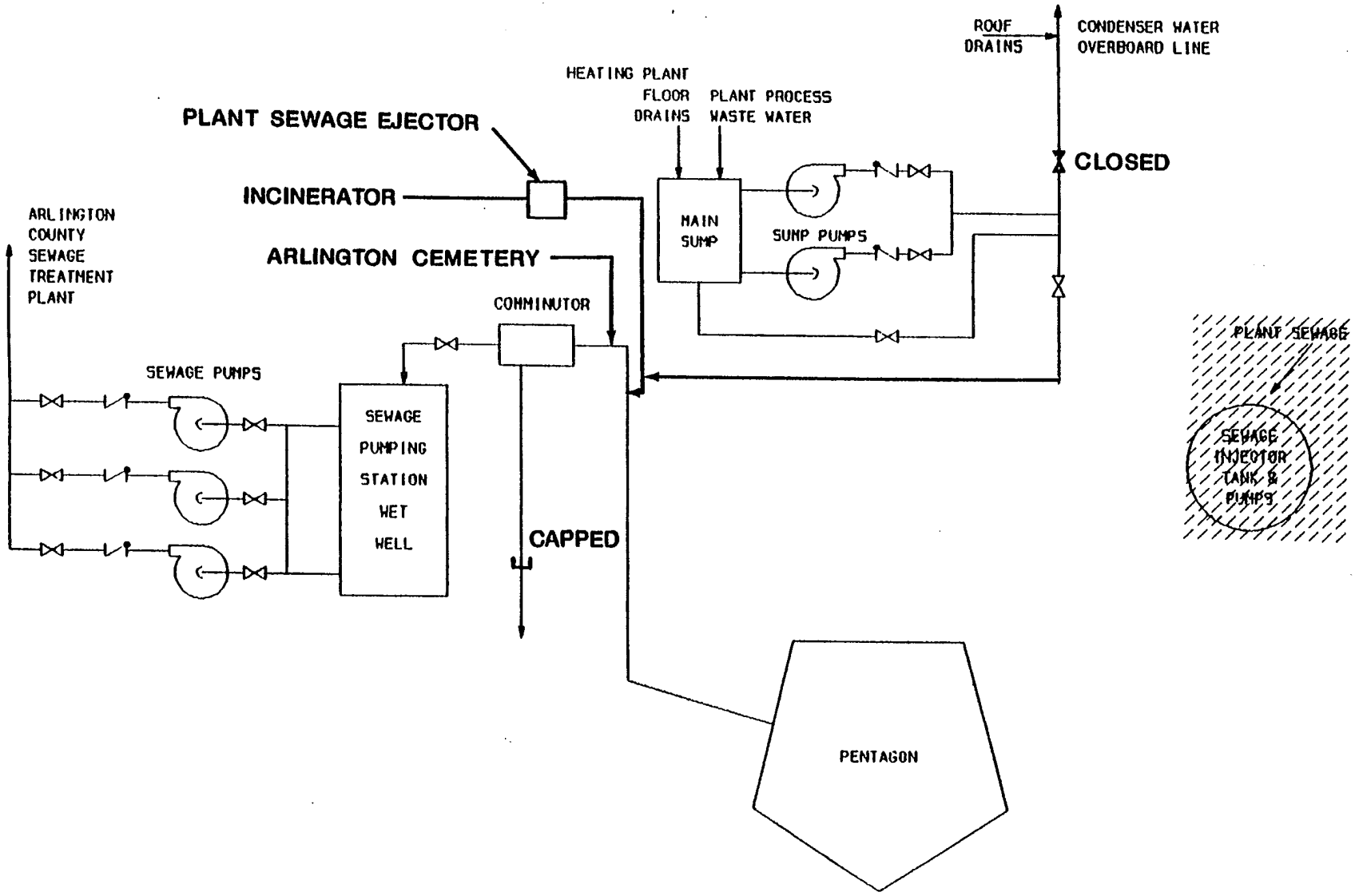

Figure A-8. Sewage System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

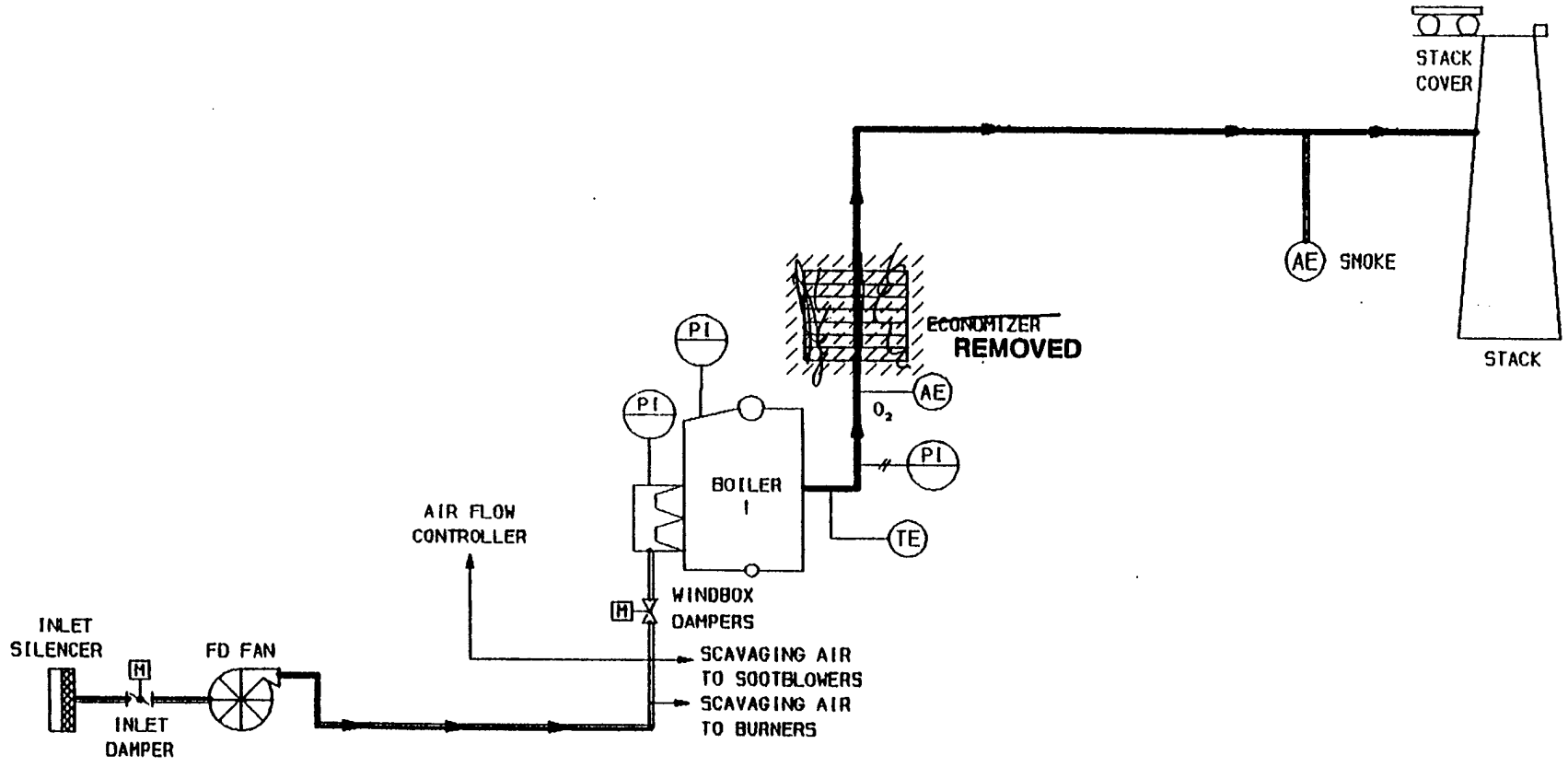

Figure A-9. Combustion Air and Flue Gas System Boiler No. 1 - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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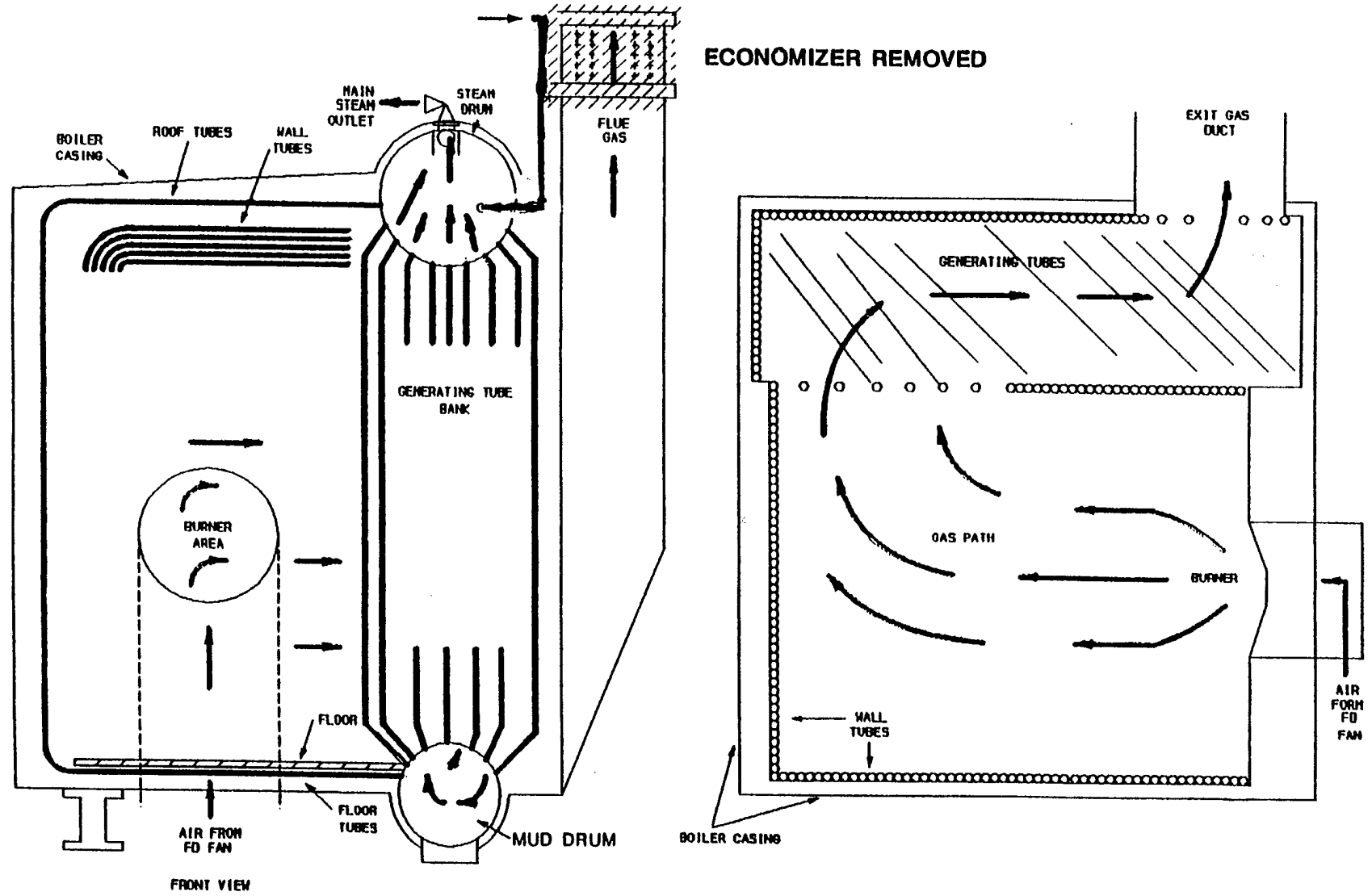

Figure A-10. Schematic Arrangement Boiler No. 1 - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

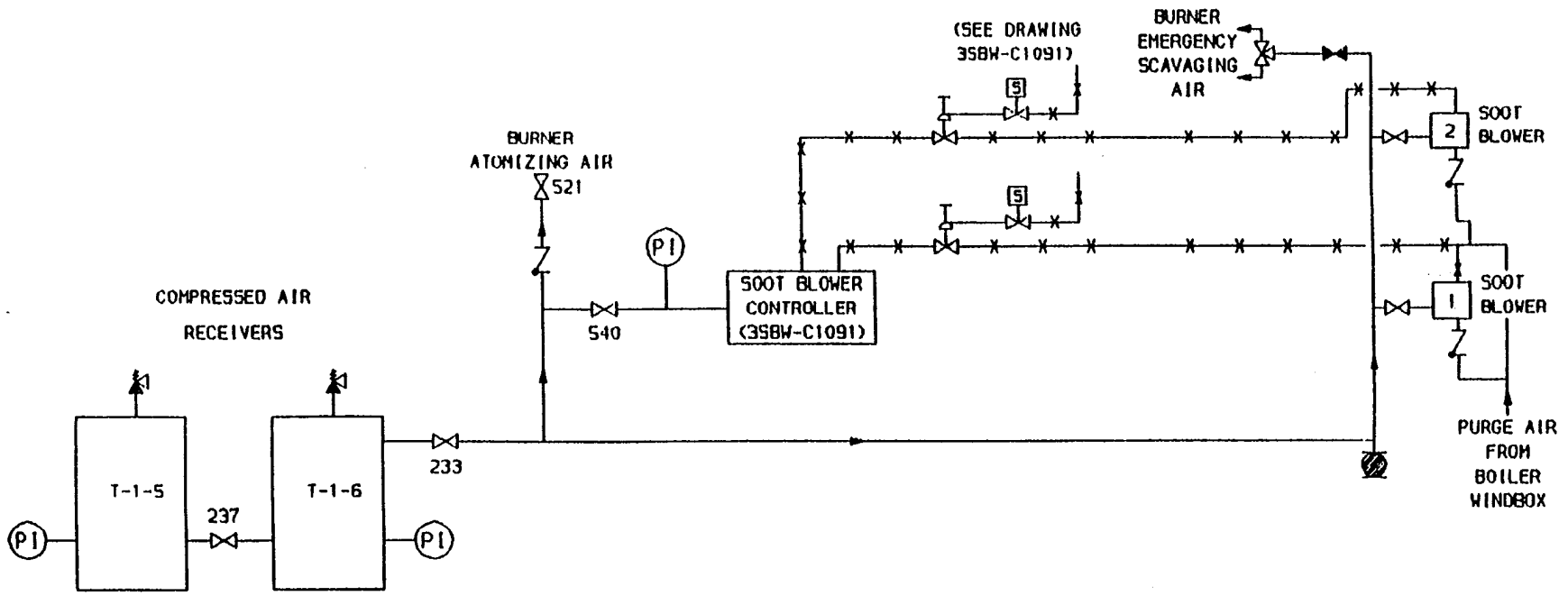

Figure A-11. Soot Blowing System Boiler No. 1 - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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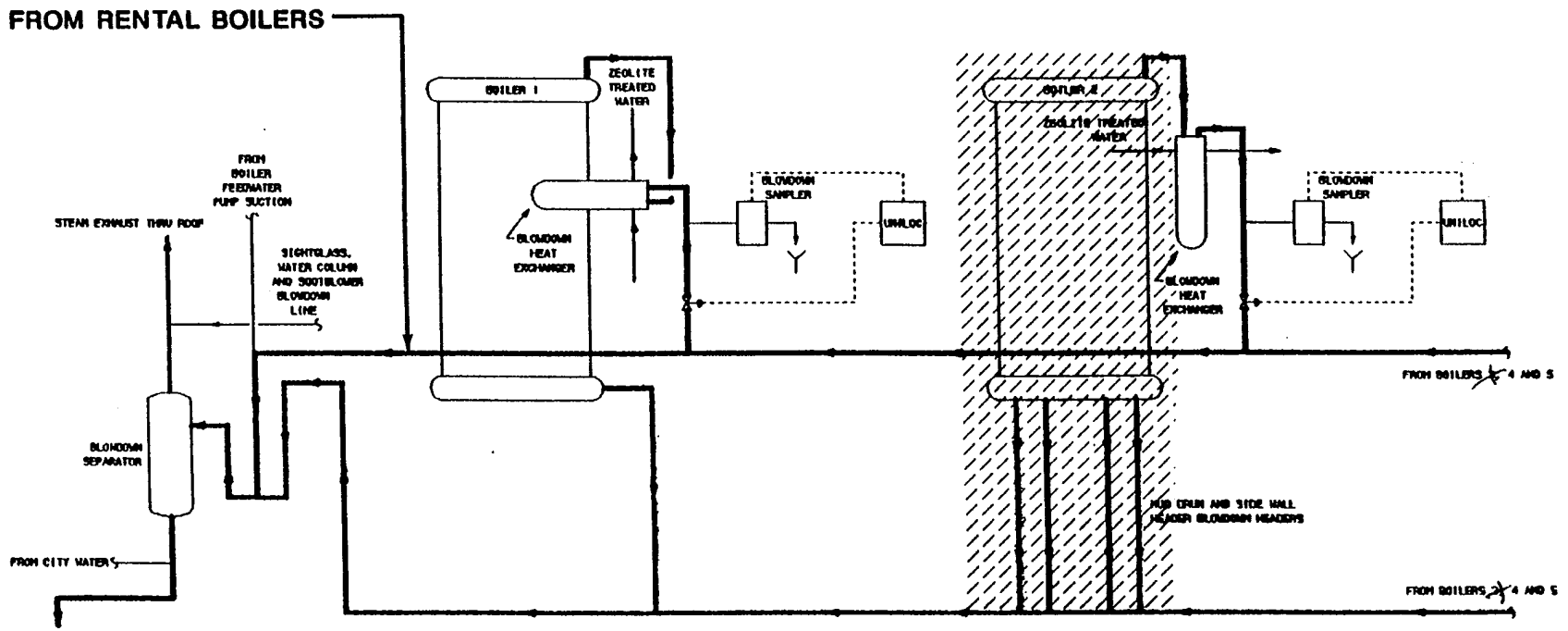

Figure A-12. Boiler Blowdown System Boiler No. 1 - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

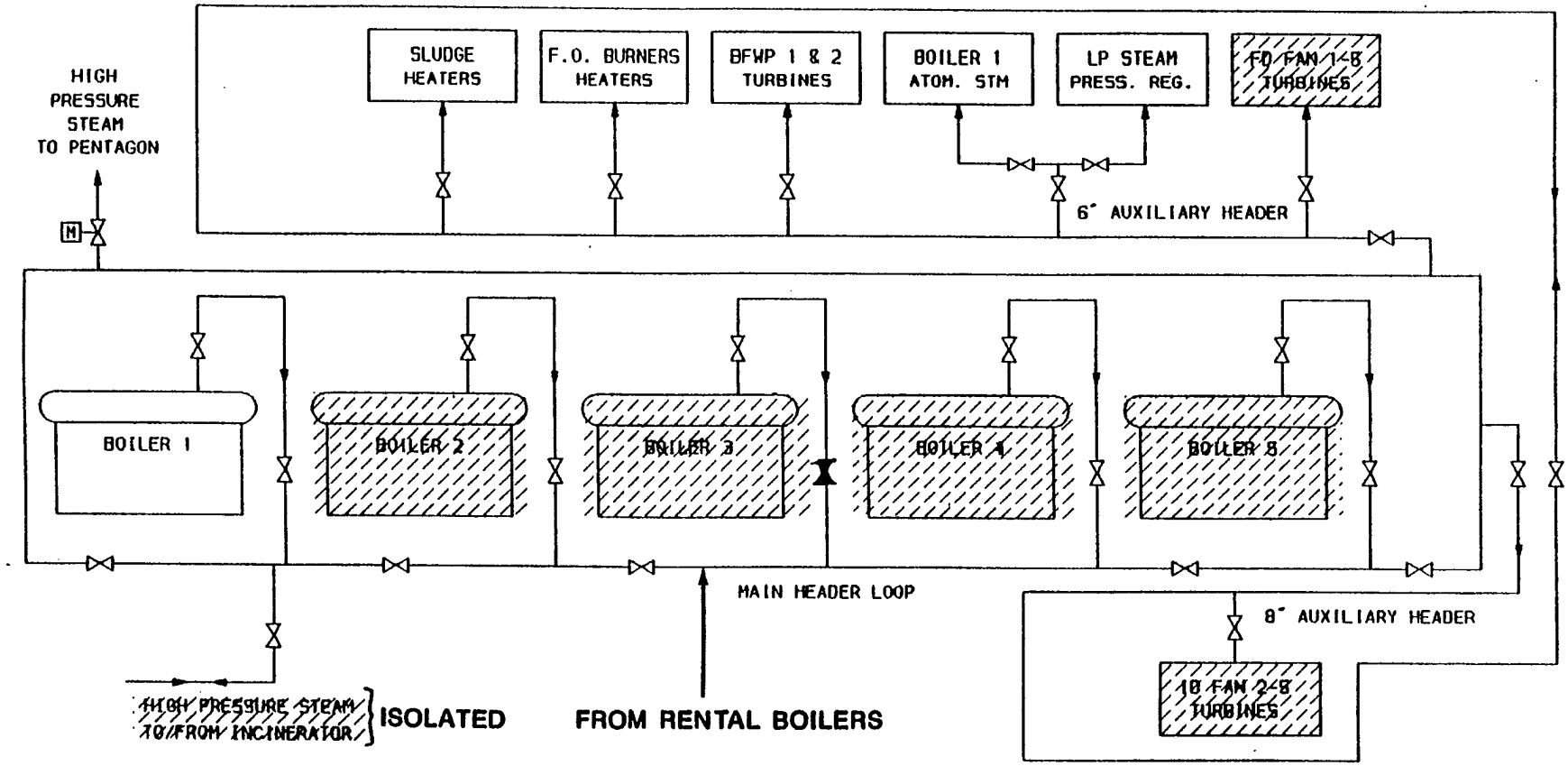

Figure A-13. High Pressure Steam Headers - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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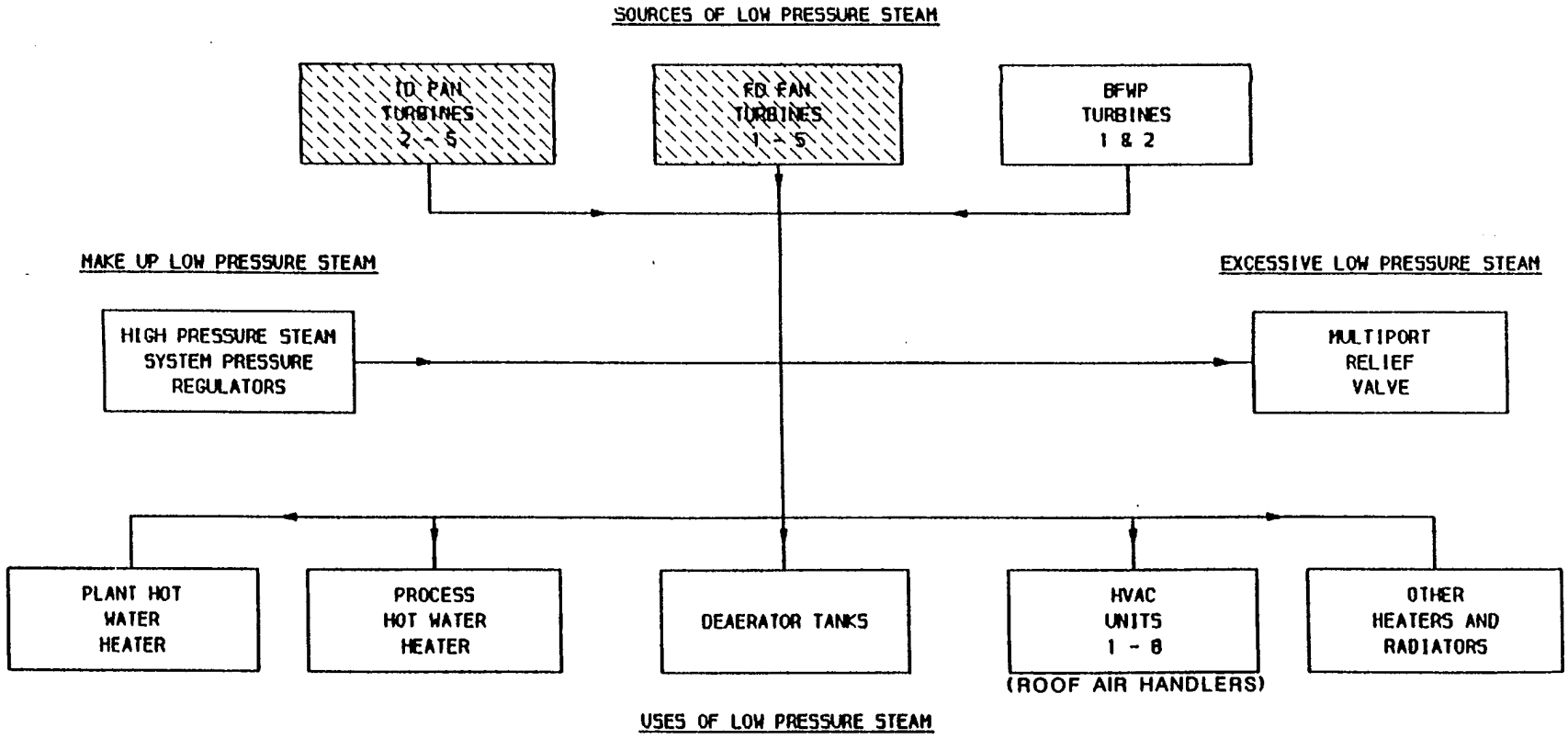

Figure A-14. Low Pressure Steam System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

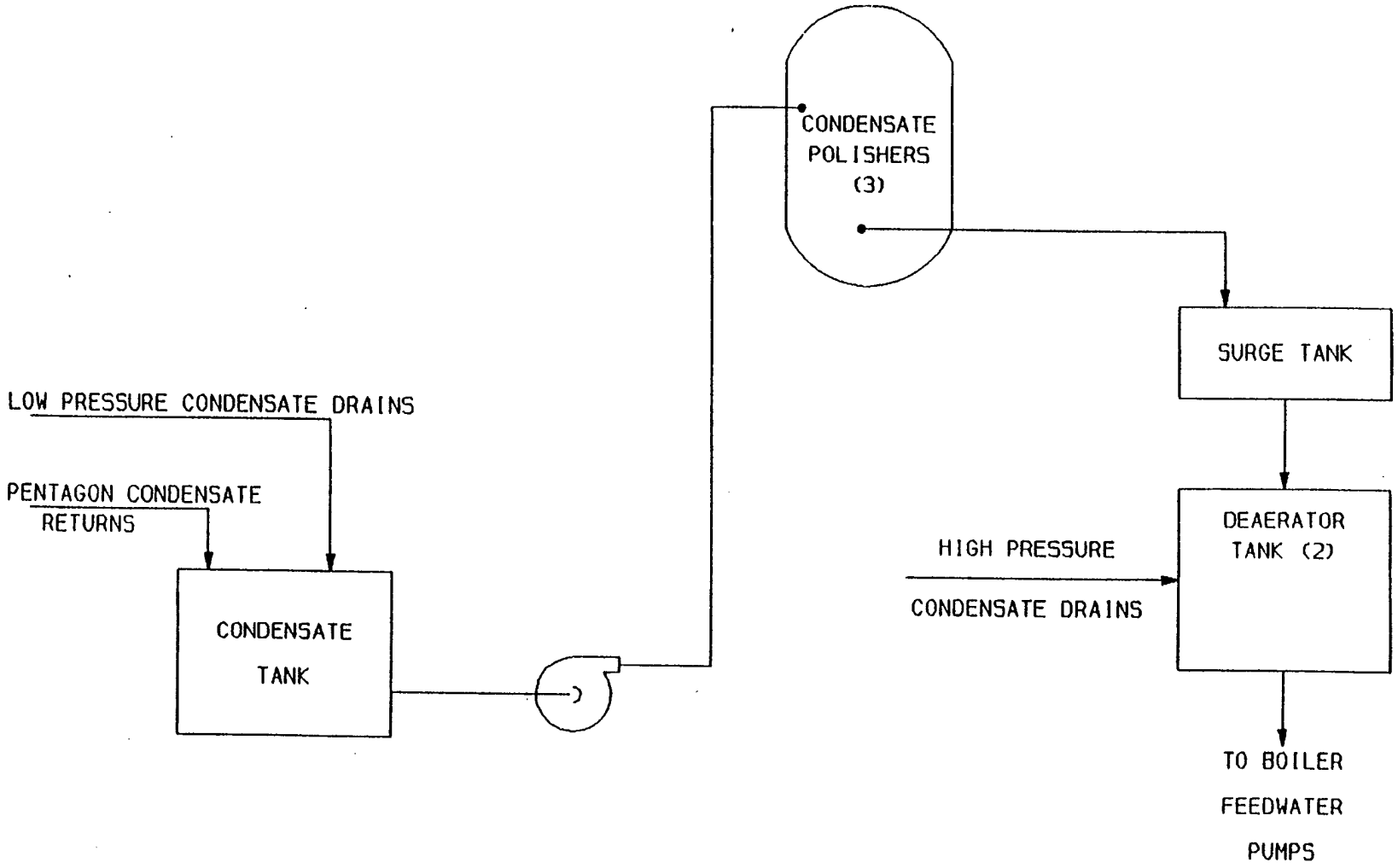

Figure A-15. Condensate Return System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

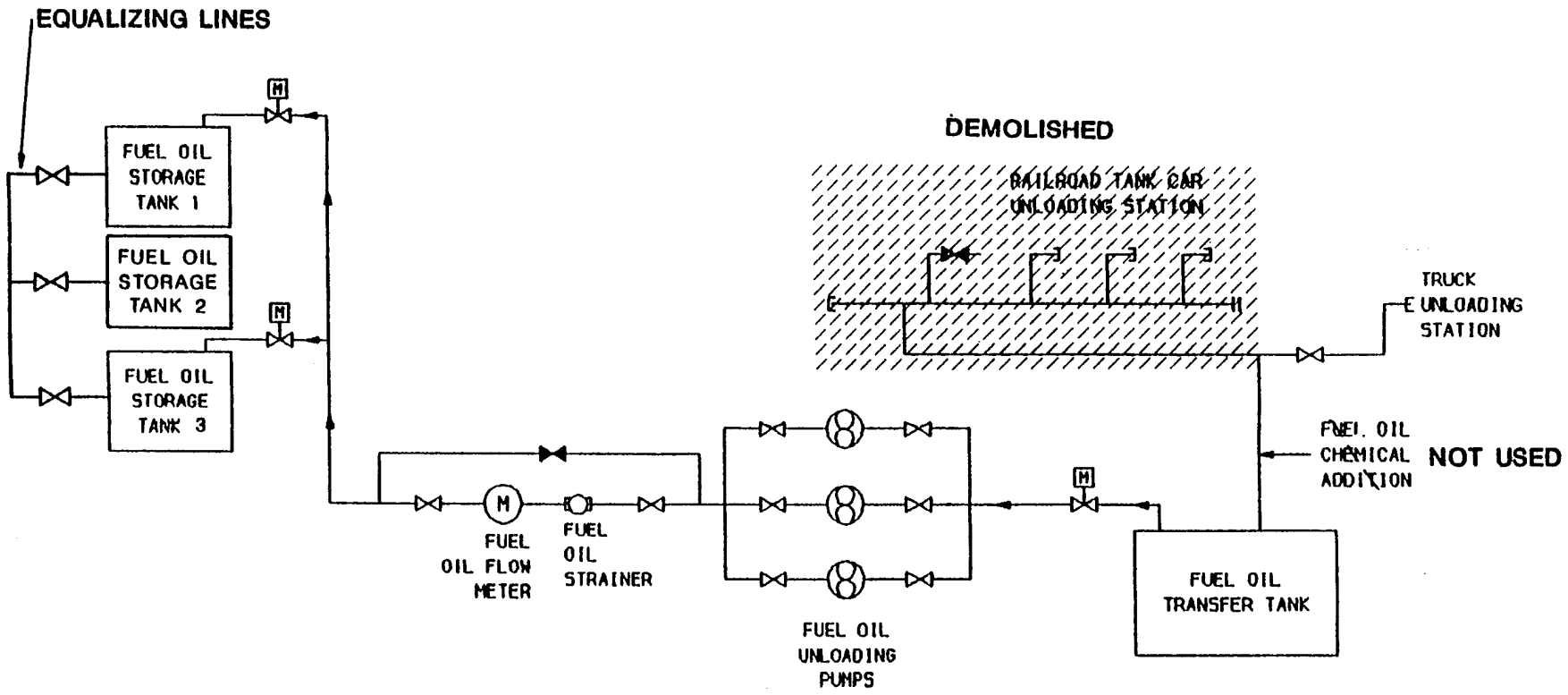

Figure A-16. Fuel Oil Handling System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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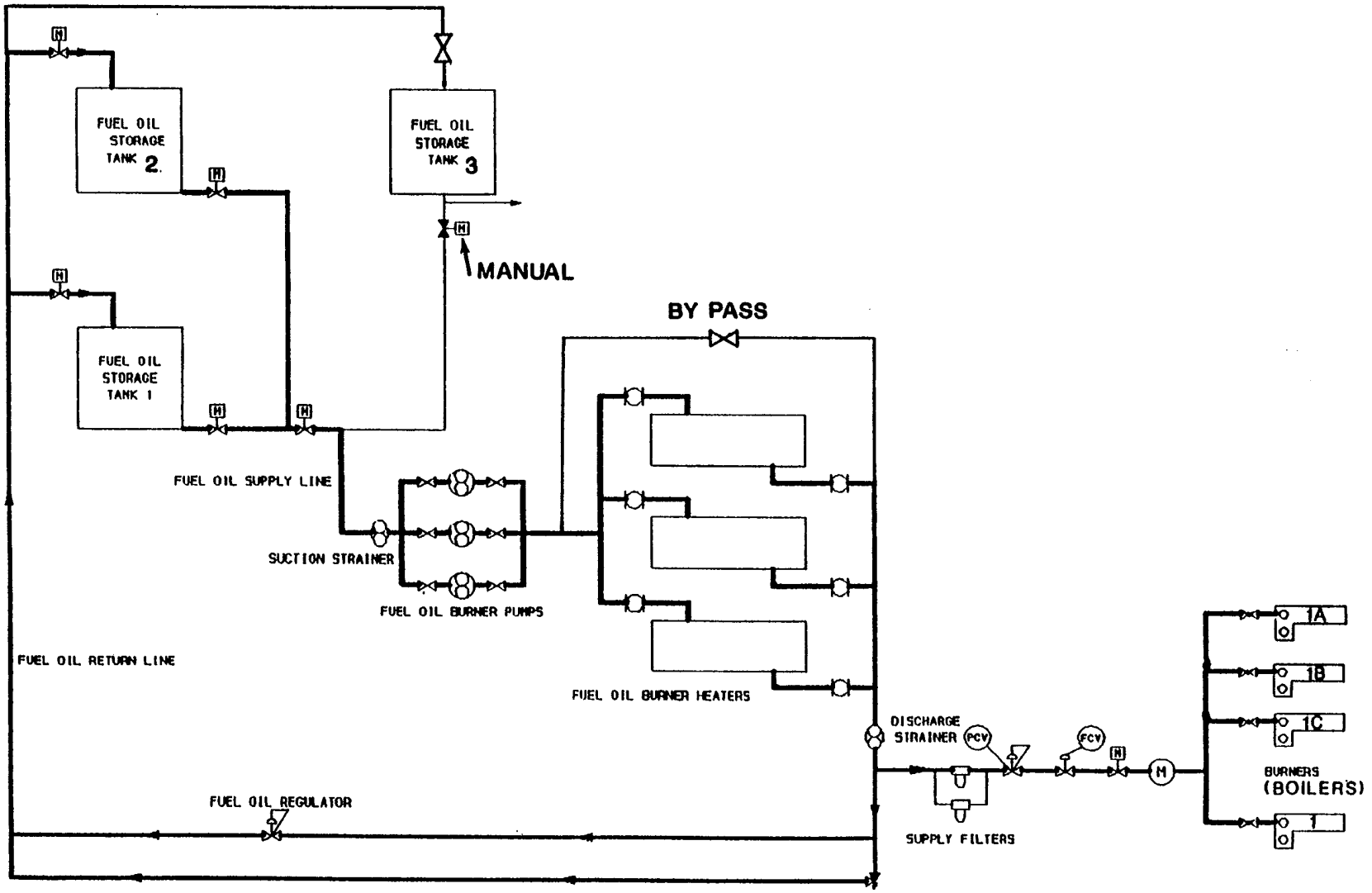

Figure A-17. Fuel Oil Firing System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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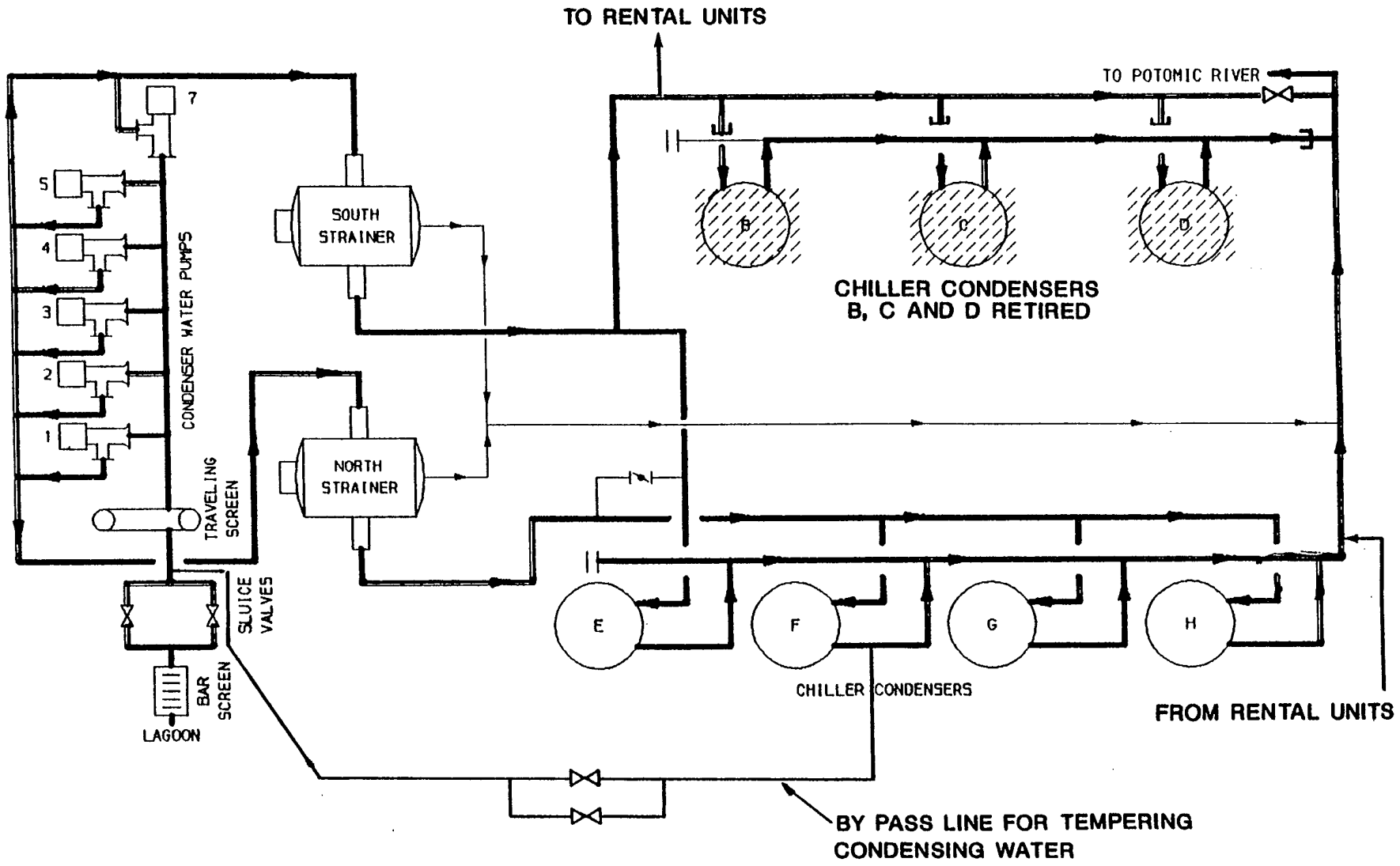

Figure A-18. Condenser Water System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

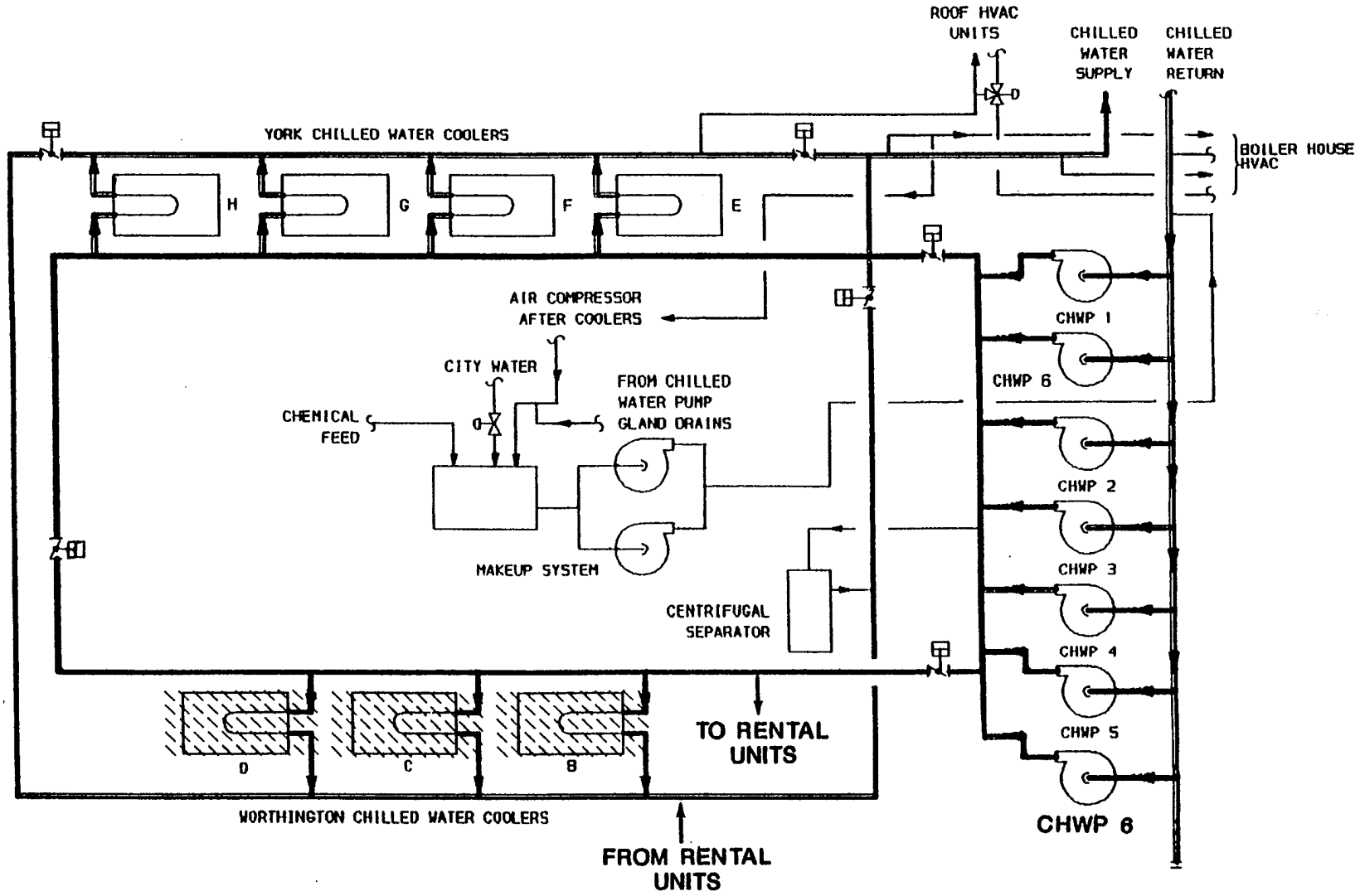

Figure A-19. Chilled Water System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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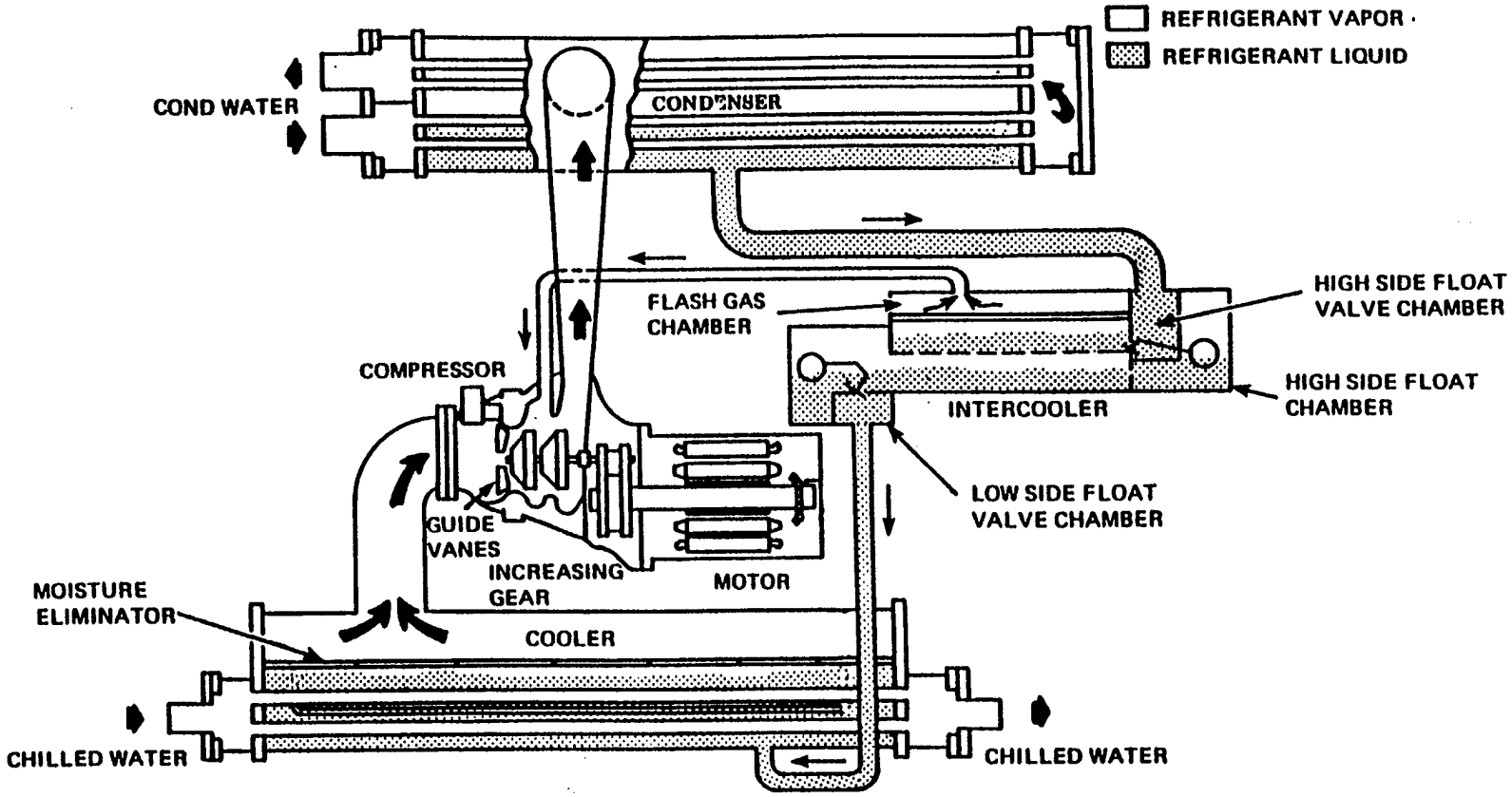

Figure A-20. Chiller System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

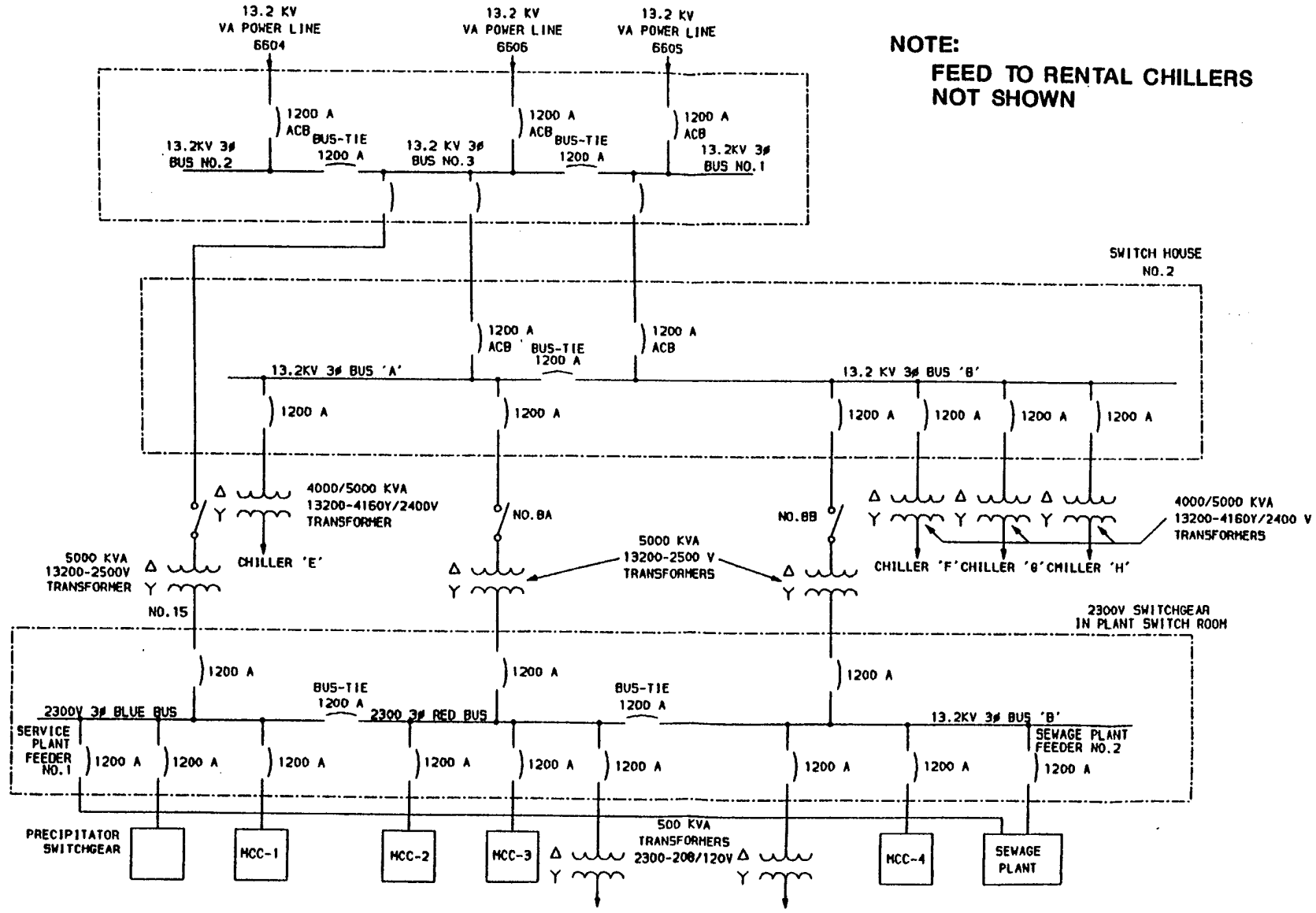

Figure A-21. High Voltage Distribution System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

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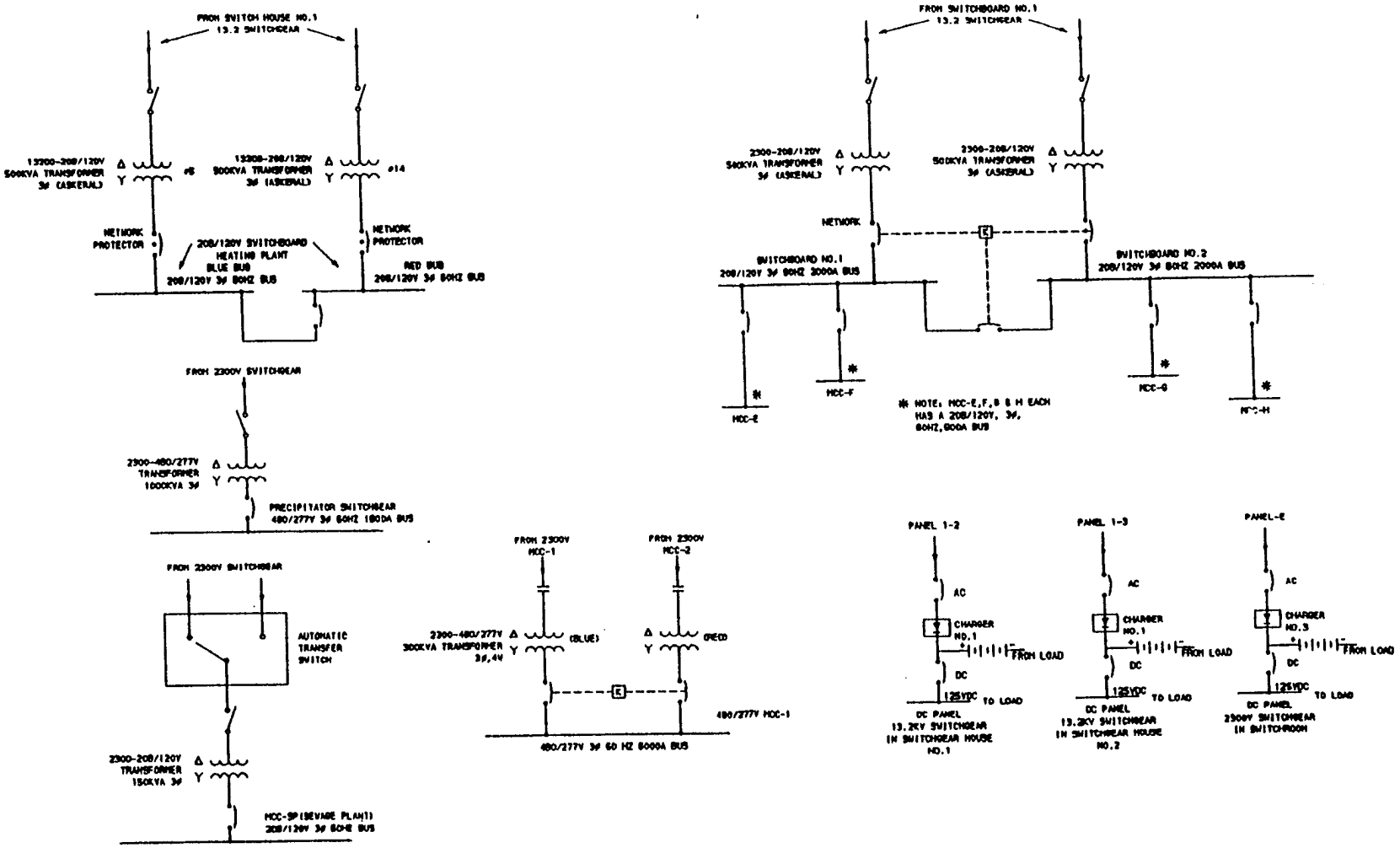

Figure A-22. Low Voltage Distribution System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

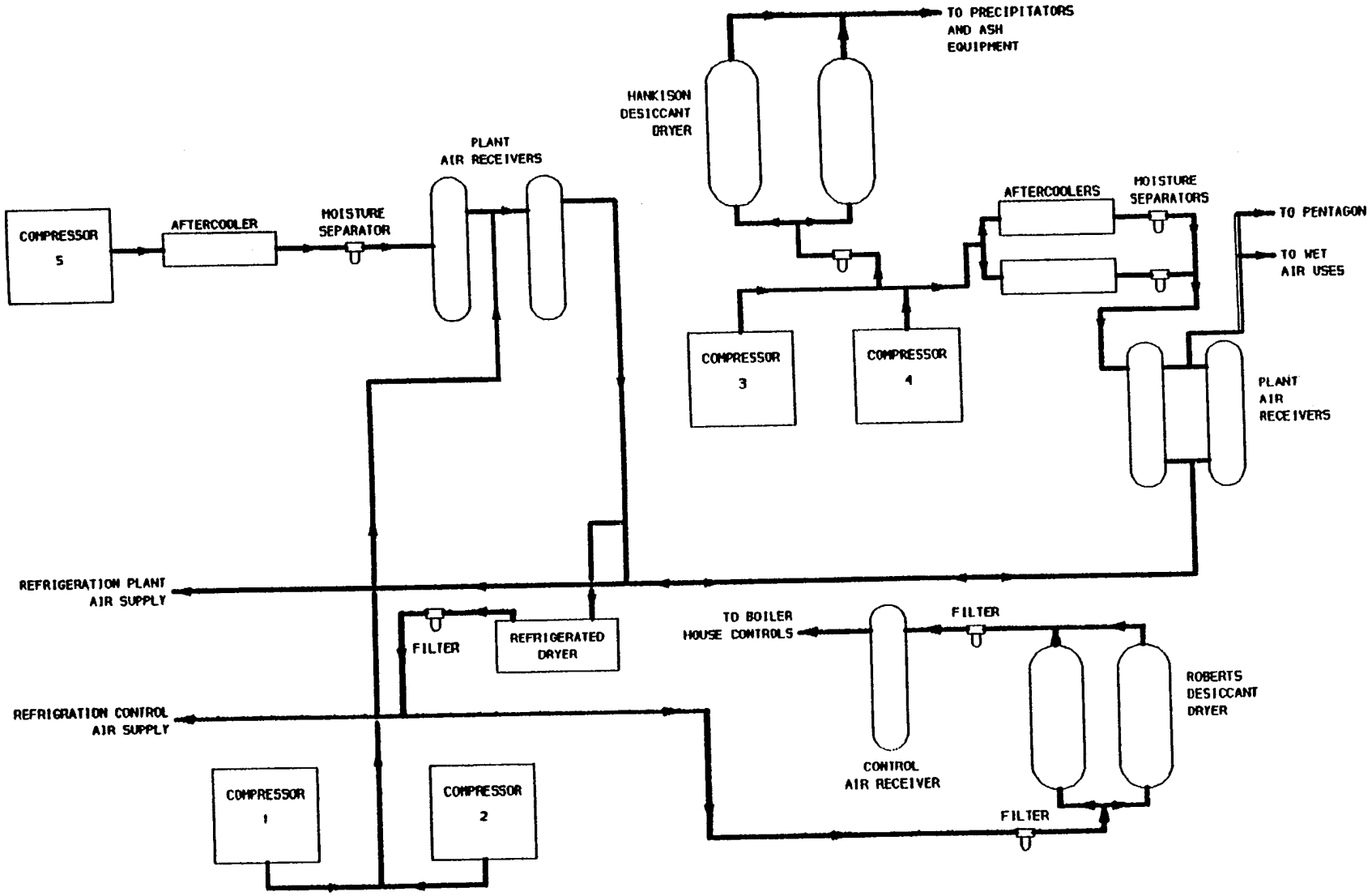

Figure A-23. Compressed Air System - Adapted From Virginia Heating and Refrigeration Plant Operations Manual, July 1987

APPENDIX A ANNEX 2

Pentagon Utilities Plant System Controls

Pentagon Utilities Plant System Controls

Overview

The Pentagon Utilities Plant includes the following major system groups:

- Feedwater-condensate systems
- Sewage systems
- Boiler systems
- Refrigeration systems
- Electrical systems
- Auxiliary systems.

The description of the controls for these systems is based on information in the *Virginia Heating and Refrigeration Plant Operations Manual* and *Training Manual,* which were prepared in 1987. These do not reflect the changes since made to the plant, including the decommissioning of four boilers and chillers, the installation of rental boilers and chillers, and the installation of new digital controls for the refrigeration systems.

Feedwater-Condensate Systems

The feedwater-condensate systems include controls for the condensate tank, condensate receiver tank level, and pump; condensate polishers; and deaerator temperature.

Condensate Tank, Condensate Receiver Tank Level, and Pump Control

The condensate receiver tank level control is maintained via two level float switches, one mechanical and one electrical, that turn the two pumps on and off. The condensate tank level control is maintained by a single level-control float switch that turns the condensate pump on and off at low and high water level setpoints, respectively.

Condensate Polisher Control

The condensate polishers are operated from a control panel near the polishers and from a solenoid valve control box at each polisher. Controls include power on/off switches, pushbuttons for reset and start regeneration, selector switches for selecting the mode of regeneration and units on stream, and controls for the sulfite pump and brine pumps.

Deaerator Temperature Control

Deaerator temperature control is maintained through a temperature sensing element that signals the actuator control valve for the low pressure steam to the deaerator.

Sewage Systems

The sewage systems include controls for the sump pumps and sewage ejector pumps.

Controls for the sump pumps are of the auto/start/stop type. In the automatic mode, the pumps are controlled by float switches. Alarms sound in the control station when the water level gets too high.

The sewage ejector pumps are equipped with hand/off/auto toggle switches. Float switches control the pumps in a lead-lag tandem mode such that a second pump is started as the water level increases. If two pumps are unable to terminate the rise in level, an alarm is set off. An alarm also detects failure of the seals on the ejector pumps. The alarms sound in the control station.

Boiler Systems

The boiler systems include controls for the combustion, steam drum level, steam flow and pressure, continuous blowdown, and blowdown separator discharge temperature control.

Combustion Control

An overview of the combustion control system is shown in Figure A2-1. The combustion control system is made up of three major control loops, which function as follows:

- The fuel oil loop regulates the fuel input to the boiler to maintain a constant supply of steam at a constant pressure.

- The combustion air control loop regulates the air input to the boiler in correct proportion to the fuel input to ensure complete combustion.

- The atomizing steam flow control loop senses the fuel oil-to-burner pressure and steam-to-burner pressure and maintains the steam pressure higher than the oil pressure.

The combustion control system includes

- transmitters for pressure, temperature, flow, level, and oxygen analyzers.

- valve positioners and electric positioners.

The main plant steam header pressure transmitter senses the plant outlet steam pressure and, through the plant master, sends a pneumatic signal to the boiler master. At the boiler master, this signal is adjusted in proportion to total plant load the operator wants the boiler to carry. From the boiler master, the signal is transmitted to the master controller on the burner front. The controller converts the pneumatic signal to an electric signal that positions the fuel oil control valve and burner registers through mechanical linkages. Forced draft inlet and outlet dampers operate together to control the air flow and furnace pressure.

The boiler control panel, located in the control room on the first floor, allows manual control of the boiler. It contains the controllers that compare or combine the various transmitter signals to produce the proper output signals to the regulating devices; it also contains various instruments for monitoring pressure, flow, and temperature.

The function of the boiler control station is to allow manual interaction with the automatic combustion controls by manually controlling the pneumatic signal to the regulating device.

The combustion control station contains

- adjustable setpoint pneumatic relay stations,

- adjustable bias pneumatic relay stations,

- manual electric control stations, and

- electric transfer control stations.

The adjustable setpoint pneumatic relay station is used for the plant master station and allows the steam pressure setpoint to be adjusted manually and allows substitution of the automatic signal with a manual signal.

The only adjustable bias relay station is the boiler master, which allows the automatic control signal to be adjusted manually (biased) by the operator to

adjust boiler load so that it represents a greater or lesser share of the total plant load.

The control stations are used for the forced draft fan control; these stations receive an automatic electric signal, which can be overridden by manual control at the control station. The electric transfer control stations perform the same function as the manual electric control stations but allow no operator adjustment.

Steam Drum Level Control

The boiler drum level is controlled by a two-element feedwater control system that sends signals to the feedwater control valve.

Steam Flow and Pressure Control

High pressure and low pressure transmitters send signals to the plant master to maintain the high pressure steam distribution system steam line pressure at 125 to 130 psig.

The high pressure steam distribution system steam line isolation valve is motor operated and controlled from the shift supervisor's office (on/off) as well as locally.

Continuous Blowdown Control

Measured conductivity of blowdown flow signals the automatic blowdown valve current to pressure transducer to adjust the air pressure on the pneumatic operator to modulate the blowdown valve.

Blowdown Separator Discharge Temperature Control

The temperature sensor on the drain line signals the temperature control valve (TPV) on the city water line. The sensor has a sensing bulb whose vapor pressure acts on the diaphragm of the TPV to adjust the valve.

Refrigeration Systems

The refrigeration systems include controls for the condenser water bar screen and traveling screen; condenser water pump, strainer, and water pit pump; chilled water; and chiller.

Condenser Water Bar Screen and Traveling Screen Controls

The condenser water bar screen rake can be operated either automatically or manually by the controls in the lagoon house located above the screen. The control panel is provided with on and off pushbuttons, a hand/off/auto switch, and hoist and lower pushbuttons. There is an audible alarm in the lagoon house and an indicating light on the bar screen control panel to alert an overtravel condition if the cable goes slack while lowering the rake.

Controls for the traveling screen are located on the control panel beside the traveling screen. Controls include a run/stop switch, a manual/off/auto switch, and a start pushbutton. The traveling screen controls also include a differential pressure switch system to operate the screen wash pumps when the screens are clogged.

Condenser Water Pump, Strainer, and Water Pit Pump Controls

Condenser water pump motors normally are controlled manually from the main chiller control panel. They can also be turned on and off from the 2,300-V switchgear room and at the pump motor itself.

The condenser water strainers are operated locally by an on/off switch on the strainer. Once the strainer is turned on, operation of the backwash collector is automatic, based on the differential pressure across the filter.

The condenser water pit pump is manually controlled by local start and stop buttons. Normally, this pump is operated approximately once a year when the condenser water pit is drained and cleaned.

Chilled Water Control

Chilled water pump motors are controlled from the chiller control panel and manually from the main switch gear room and with a stop lockout pushbutton directly on the pump motor.

The chilled water system pressure is controlled first by the chilled water pumps and then is fine-tuned manually by controlling the compressed air supply to the balance tanks in the Pentagon.

The chilled water makeup system is controlled manually by the operator. By opening or closing the chilled water makeup flow control valve, the operator controls the amount of makeup water that is pumped into the system. Two makeup pumps are turned on and off by level switches in the makeup tank. The level switch also alternates the lead/lag control of the pumps so that alternate pumps start each time.

The chilled water air operated valves are isolation valves that control the flow path of the chilled water system. These valves are controlled by remote switches on the chiller control panel on the main floor.

Chiller Control[1]

Chiller compressor motors are controlled by start and stop pushbuttons located on each chiller control panel. The motor is interlocked with the chiller controls so that the following permissives are met before the system started:

- Chilled water flow
- Chilled water temperature
- Compressor oil pressure differential pressure
- Compressor oil temperature
- Compressor pressure
- Compressor discharge temperature
- Gear/motor oil pressure and temperature
- Motor temperature
- Motor winding and bearing temperatures
- Time since last start.

The chiller compressor flow rate is controlled by an automatic pneumatic system depicted in Figure A2-2. The operator can control the system from a manual/auto station that controls the air signal to the hot gas bypass valve operator positioner. Electrical controls are used for the interlock devices listed above.

The compressor and gear/motor oil system are controlled directly by the compressor control system. Both of the auxiliary oil pumps may be manually operated when the switch on the chiller control panel is in the manual position.

The refrigerant pump-out system is used to transfer refrigerant. The pump-out compressor is controlled from local start and reset pushbuttons. The compressor is equipped with high and low pressure cutouts and with a low oil pressure cutout.

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[1] This description of the chiller system controls is based on the outdated system description and does not reflect the capabilities of the added digital control systems.

The air purge unit is manually controlled. The purge unit is put into operation when the indicators show an excessive amount of noncondensible gases in the condenser.

The discharge pressure control system varies the flow of water through the condenser to maintain the compressor discharge pressure at the setpoint. The discharge pressure control system is located at the control panel outside each chiller room. The controller may operate either in manual or automatic.

Additional local control switches are provided for the refrigerant gas leak detection system, thermocycle system, and cubicle exhaust fan control.

ELECTRICAL SYSTEMS

The electrical systems include controls for the high voltage switchgear, motor control centers, switchboard, and direct current (DC) system.

13.2-kV Switchgear Control

The control switches and indicators for the 13.2-kV switchgear are located in Switchhouses No. 1 and No. 2. Alarms are provided in the plant's switchgear room.

2,300-V Switchgear Control

Control switches, indicating lights, and alarms are mounted locally on the switchgear enclosures.

2,300-V Motor Control Centers (Chiller Motors) Control

Control switches and indicating lights are mounted on the motor control centers. An alarm, located in the plant's refrigeration room, indicates when a 2,300-V motor control center main contactor has tripped.

208/120-V Switchboard Control

Operation of the 208/120-V switchboards is controlled local, with manual breakers. The refrigeration switchboard is designed to allow the operator to select either one of the two incoming feeders manually to feed the switchboard load. Key interlocks permit only one circuit breaker to be closed at a time. Alarms are provided on the switchboard in the refrigeration plant.

DC System Control

AUXILIARY SYSTEMS

The auxiliary systems include controls for the air compressors; air dryers; crane and elevator; heating, ventilation, and air conditioning system; vacuum systems; and fire protection system.

Air Compressor Control

The single-stage compressor is turned off and on by local start and stop pushbuttons. A pressure switch on the attached compressor air receiver starts and stops the compressor as needed to keep the pressure between 80 and 100 psig.

The two-stage compressors are controlled by a discharge pressure switch and a start-up timer to keep the pressure between 90 and 110 psig. Compressors 3 and 4 are also equipped with a toggle switch and a hand/off/auto station. The toggle switch determines which compressor will start in response to a low pressure signal. The hand/off/auto switch allows manual operation.

Air Dryers Control

The desiccant air dryers are controlled locally by on/off switches and timers. The refrigerated dryer is turned on and off by a local switch.

Crane and Elevator Control

The overhead crane is controlled from the pushbutton control box, which hangs from the crane trolley. The elevator has a standard selective control system.

Heating, Ventilation, and Air Conditioning System and Vacuum System Controls

Building room thermostats control the fan motor and inlet dampers for heating and cooling. The heating and cooling units are turned on or off by local start/stop and fast/slow/stop pushbuttons. The vacuum producer motor is controlled by a set of local start and stop pushbuttons.

Fire Protection System Control

When in the automatic control mode, the foam fire protection system is actuated by two heat-sensitive devices located at the fuel oil unloading tank. The system also can be tested and activated manually from a control panel located near the foam concentration tank and pump.

The standpipe and water sprinkler system is automatically controlled with fusible links that burst at high temperature.

APPENDIX B

New Heating and Refrigeration Plant Systems Description

New Heating and Refrigeration Plant Systems Description

General Arrangement

The Pentagon New Heating and Refrigeration Plant (NHRP) has three basic sections: the boiler plant, the refrigeration plant, and the exterior, which includes the sewage handling systems. Figures B1-1 through B1-7 show the general arrangement of the plant. For construction planning purposes, the NHRP is divided into seven sections as shown on the key plan on the figures. The refrigeration plant occupies Sections 1 – 4, and the heating plant occupies Sections 5 – 7. The electrical switchgear/load centers are located in Sections 3 and 4 between the refrigeration and heating plant. Administration offices are located in Section 7. The control room is located above one of the electrical load centers, overlooking both the chiller room and boiler room.

The NHRP's major systems are listed below:

- Steam generation systems
  - Boiler
  - Soot blowing
- Feedwater and water treatment systems
  - Boiler feedwater
  - Water treatment and condensate polishing
  - Chemistry control (including boiler blowdown)
- Fuel storage and supply systems
- Steam distribution and condensate return systems
  - High pressure steam
  - Low pressure steam
  - Condensate return
- Refrigeration systems
  - Condenser water

- Chiller
- Chilled water distribution

- Auxiliary systems
  - Compressed air
  - City water
  - Plant services
  - Fire protection
- Sewage system
- Electrical systems
  - High voltage
  - Low voltage

The principal features of the NHRP systems are discussed below.

STEAM GENERATION SYSTEMS

The steam generation systems, which provide steam to the steam distribution system, include the boiler and the soot blowing systems.

Boiler System

The steam generation system includes six boilers and their associated soot blowing and blowdown systems. Each boiler has a design capacity of 40,000 pounds per hour of saturated steam at 125 psig (353°F) and may be fired with natural gas, No. 2 fuel oil, or No. 6 fuel oil. The primary fuel is expected to be natural gas. The boilers are forced draft units, and each boiler is equipped with its own forced draft fan.

Each boiler consists of a steam drum, which allows for the distribution and separation of incoming feedwater and outgoing steam, and a lower water drum that supplies water to the waterwall and steam generating tubes. The steam drum is equipped with outlet connections that allow for venting, overpressure protection (safety valves), steam discharge, and blowdown. The water drum is equipped with drain and blowdown lines. Each boiler is also provided with an economizer, which preheats the feedwater prior to injection into the steam drum.

The lower water drum on each boiler is provided with an insertable/removable steam immersion heater. This heater can be used to keep the boiler surfaces warm when the boiler is being maintained in a standby mode. Steam for the immersion heaters is provided by the high pressure steam distribution system (see Figure B1-8).

Soot Blowing System

The soot blowing system for each boiler consists of two steam soot blowers: one for the boiler convection steam generating tubes and one for the economizer. The soot blowers are designed to operate with 125 psig saturated steam. The blowers are controlled through a control panel to keep the boiler fireside surfaces clean. The soot blowers are utilized as often as necessary, and according to boiler operating conditions, to maintain efficient steam generation.

Feedwater and Water Treatment Systems

The feedwater and water treatment systems include the boiler feedwater, water treatment and condensate polishing, and chemistry control systems.

Boiler Feedwater System

Water is provided to the boilers by the boiler feedwater system. As shown in Figure B1-9, the system consists of two deaerators, which heat and deaerate the feedwater, and six feedwater pumps, which transfer the feedwater to the boilers. The feedwater pumps provide water to a single header from which all six boilers are fed.

The smaller of the two deaerators is rated for a feedwater flow rate of 50,000 pounds per hour. The other deaerator is rated for a feedwater flow rate of 240,000 pounds per hour. Saturated steam is provided to the deaerators from the low pressure steam system.

Two feedwater pumps take suction from the smaller deaerator. These pumps have a design operating point of 102 gallons per minute (gpm) with a total developed head of 443 feet. Two of the four feedwater pumps that take suction from the larger deaerator also have a design operating point of 102 gpm with a total developed head of 443 feet. The other two pumps have a design operating point of 204 gpm with a total developed head of 443 feet.

Each feedwater pump is provided with a minimum flow line to prevent pump damage during periods of low flow operation. This line recirculates water from the pump discharge back to the associated deaerator. (Note: P&ID does not show check valves in the pump discharge lines downstream of the minimum flow line connection. As a result, the lines may not adequately protect the pumps.)

Water Treatment and Condensate Polishing Systems

The water treatment and condensate polishing systems treat raw city water to produce softened water for use as makeup to the steam generation system. In addition, the condensate polishing system treats low pressure condensate returned from the steam/condensate distribution system (see Figure B1-9).

The treated water and condensate polishing systems each consist of two full-capacity, resin-bed water softeners. The softeners remove scale-producing compounds from the water. Piping and valves are provided to allow one softener resin bed to be regenerated while the other softener is in service.

A common brine system provides brine to both the water treatment and condensate polishing system softeners for resin regeneration.

Chemistry Control System (Including Boiler Blowdown)

The chemistry control system consists of a sampling system to monitor feedwater, steam, and boiler water chemistry; a continuous blowdown system to reduce the contamination levels in the boiler water; and three chemical stations to supply chemicals to the steam generating system as required. A single control panel is provided for control of the three chemical stations (see Figure B1-8).

The boiler blowoff and blowdown system, illustrated in Figure B1-11, contains blowdown control valves that regulate the flow of boiler water into the blowdown system, a blowdown heat exchanger to reduce the loss of heat and steam from the continuous boiler blowdown water, and a blowoff tank to separate and dispose of flash steam and hot blowdown water. This system provides the means by which water containing dissolved and undissolved solids are removed from the boiler steam drum and water drum.

Operation of the boiler blowdown system is supported by several other systems:

- City water system, which provides water to the blowoff tank drain to cool water entering the drain system from the blowoff tank
- Plant sewage system, which pumps blowdown water and condensate from the blowoff tank to the city sanitary sewer system
- Automatic conductivity control system.

Steam Distribution and Condensate Return Systems

The steam distribution and condensate return systems consist principally of high and low pressure piping for the distribution of steam and return of condensate.

High Pressure Steam System

The function of the high pressure steam system is to route the steam generated in the boilers through a steam distribution system to the Pentagon, FOB 2, and Henderson Hall where the steam is used for space heating, cafeteria use, and cleaning. In addition, the system also provides high pressure steam throughout the NHRP for operating auxiliary plant equipment, such as sootblowers and the pressure powered condensate pump, and for heating feedwater and fuel oil (see Figure B1-8).

High pressure steam is supplied from each of the boilers to an 18-inch supply header. Connections off the supply header consist of small branch lines for the soot blowers and heaters, a 6-inch line to the low pressure steam system, and two 16-inch headers that supply steam to the steam distribution system through the tunnels.

The steam distribution system supplies high pressure steam for heating the Pentagon and other government buildings. A new ring header will be installed in the inner court of the Pentagon to enable isolation of sections of the Pentagon. Installation of the new ring header will be done in phases as the renovation is carried out. Thus, the existing outer header will be the only distribution header in operation for an extended period of time (probably 10 years).

The high pressure steam system is equipped with a condensate drain system that collects high pressure condensate. This drain system protects the steam system piping and components from water hammer damage.

Low Pressure Steam System

The function of the low pressure steam system is to supply steam to the deaerators for feedwater heating. The low pressure steam system consists of a set of pressure control valves and associated piping. High pressure steam is supplied to the system through a 6-inch supply line. The steam pressure is reduced and the low pressure steam is provided to the deaerators where it is used to heat and remove noncondensable gases from the feedwater (see Figure B1-8).

Condensate Return System

As the steam cools it condenses. High pressure condensate from the Pentagon steam supply piping and from the plant high pressure steam piping drains is returned directly to deaerators.

Low pressure condensate, including that from the low pressure drains, the buildings, and the HVAC system inside the plant, is directed to the condensate receiver. From the condensate receiver, it is pumped by the condensate lift pumps to the condensate storage tank. Condensate transfer pumps are used to pump condensate from the condensate storage tank through the condensate polishers to the deaerators (see Figure B1-8).

Condensate from the fuel oil tank heaters is not reused. This condensate is pumped to the blowoff tank by a pump powered by steam from the high pressure steam header.

Two of the condensate transfer pumps are designed for a total developed head of 131 feet at 194 gpm. The other two pumps have a design flow rate of 97 gpm with a total developed head of 131 feet.

The two condensate lift pumps are designed for a total developed head of 52 feet at 125 gpm.

Fuel Storage and Supply Systems

The fuel storage and supply systems include both the natural gas and fuel oil handling and firing systems.

Natural gas is supplied from a gas main to the natural gas header used to supply gas to the individual boilers.

The fuel oil handling system consists of an unloading station and fuel oil transfer pumps for the delivery of fuel oil from delivery vehicles to the two 300,000-gallon fuel oil storage tanks. To ensure that the fuel oil can be transferred to the boilers under severe weather conditions, heat tracing is provided on some of the fuel oil lines. In addition, each storage tank is equipped with a fuel oil suction heater. The heater receives steam from the high pressure steam distribution system. Condensate from the heaters is directed to the blowoff tank (Figures B1-8, B1-17, and B1-18).

The fuel oil firing system contains six fuel oil pumps that take suction on the fuel oil storage tanks. The pumps supply fuel to a common header that supplies fuel to all of the boilers. The header pressure is controlled by a pressure control valve that controls the recirculation rate of fuel oil from the supply header back to the storage tanks. To increase the efficiency of the steam atomizing burners, fuel oil heaters are provided just upstream of the burners. The steam is supplied

to the heaters and for fuel oil atomization from the high pressure steam distribution system (see Figures B1-8 and B1-18).

REFRIGERATION SYSTEMS

The refrigeration systems include the condenser water, chiller, and chilled water distribution systems.

Condenser Water System

The function of the condenser water system is to provide cooling water to the refrigeration plant chillers for removing heat contained in the refrigerant (see Figures B1-3 and B1-14).

The condenser water source is the Potomac River via the lagoon adjoining Columbia Island. Water from the river enters the east and west condenser water "sumps" after passing through a bar screen and sluice gates located at the lagoon. The design inlet condenser water temperature for the chillers is 82°F.[1]

The water passes through traveling screens as it enters the sumps. Five condenser water pumps take suction on each of the two sumps (a total of 10 pumps). The water passes through an automatic backwash strainer at the discharge of each pump and then to one of two 54-inch headers from which it is distributed to the chillers. The east and west condenser water headers are cross-connected by a 42-inch line. After passing through the chillers, the water is returned to the river; some of the return water may be directed back to the pump intake pits to control inlet water temperature.

Three screen wash pumps take suction on the condenser water headers. These pumps supply water for washing the traveling screens.

A sump dewatering pump is provided for draining each of the condenser water sumps.

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[1]Temperatures in the lagoon have exceeded the design limit by a few degrees on some occasions (up to about 91°F). A study has been initiated to evaluate the feasibility of adding a second set of intake-outfall lines directly to the Potomac River; these could provide lower temperature water than the existing lines and would allow maintenance to be performed on a routine schedule. Currently, maintenance is performed during a short period around Presidents' Day.

APPENDIX B

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The NHRP's major systems are listed below:

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  - Water treatment and condensate polishing
  - Chemistry control (including boiler blowdown)
- Fuel storage and supply systems
- Steam distribution and condensate return systems
  - High pressure steam
  - Low pressure steam
  - Condensate return
- Refrigeration systems
  - Condenser water

- Chiller
- Chilled water distribution

- Auxiliary systems
  - Compressed air
  - City water
  - Plant services
  - Fire protection
- Sewage system
- Electrical systems
  - High voltage
  - Low voltage

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STEAM GENERATION SYSTEMS

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The lower water drum on each boiler is provided with an insertable/removable steam immersion heater. This heater can be used to keep the boiler surfaces warm when the boiler is being maintained in a standby mode. Steam for the immersion heaters is provided by the high pressure steam distribution system (see Figure B1-8).

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The soot blowing system for each boiler consists of two steam soot blowers: one for the boiler convection steam generating tubes and one for the economizer. The soot blowers are designed to operate with 125 psig saturated steam. The blowers are controlled through a control panel to keep the boiler fireside surfaces clean. The soot blowers are utilized as often as necessary, and according to boiler operating conditions, to maintain efficient steam generation.

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The water treatment and condensate polishing systems treat raw city water to produce softened water for use as makeup to the steam generation system. In addition, the condensate polishing system treats low pressure condensate returned from the steam/condensate distribution system (see Figure B1-9).

The treated water and condensate polishing systems each consist of two full-capacity, resin-bed water softeners. The softeners remove scale-producing compounds from the water. Piping and valves are provided to allow one softener resin bed to be regenerated while the other softener is in service.

A common brine system provides brine to both the water treatment and condensate polishing system softeners for resin regeneration.

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The steam distribution and condensate return systems consist principally of high and low pressure piping for the distribution of steam and return of condensate.

High Pressure Steam System

The function of the high pressure steam system is to route the steam generated in the boilers through a steam distribution system to the Pentagon, FOB 2, and Henderson Hall where the steam is used for space heating, cafeteria use, and cleaning. In addition, the system also provides high pressure steam throughout the NHRP for operating auxiliary plant equipment, such as sootblowers and the pressure powered condensate pump, and for heating feedwater and fuel oil (see Figure B1-8).

High pressure steam is supplied from each of the boilers to an 18-inch supply header. Connections off the supply header consist of small branch lines for the soot blowers and heaters, a 6-inch line to the low pressure steam system, and two 16-inch headers that supply steam to the steam distribution system through the tunnels.

The steam distribution system supplies high pressure steam for heating the Pentagon and other government buildings. A new ring header will be installed in the inner court of the Pentagon to enable isolation of sections of the Pentagon. Installation of the new ring header will be done in phases as the renovation is carried out. Thus, the existing outer header will be the only distribution header in operation for an extended period of time (probably 10 years).

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The function of the low pressure steam system is to supply steam to the deaerators for feedwater heating. The low pressure steam system consists of a set of pressure control valves and associated piping. High pressure steam is supplied to the system through a 6-inch supply line. The steam pressure is reduced and the low pressure steam is provided to the deaerators where it is used to heat and remove noncondensable gases from the feedwater (see Figure B1-8).

Condensate Return System

As the steam cools it condenses. High pressure condensate from the Pentagon steam supply piping and from the plant high pressure steam piping drains is returned directly to deaerators.

Low pressure condensate, including that from the low pressure drains, the buildings, and the HVAC system inside the plant, is directed to the condensate receiver. From the condensate receiver, it is pumped by the condensate lift pumps to the condensate storage tank. Condensate transfer pumps are used to pump condensate from the condensate storage tank through the condensate polishers to the deaerators (see Figure B1-8).

Condensate from the fuel oil tank heaters is not reused. This condensate is pumped to the blowoff tank by a pump powered by steam from the high pressure steam header.

Two of the condensate transfer pumps are designed for a total developed head of 131 feet at 194 gpm. The other two pumps have a design flow rate of 97 gpm with a total developed head of 131 feet.

The two condensate lift pumps are designed for a total developed head of 52 feet at 125 gpm.

Fuel Storage and Supply Systems

The fuel storage and supply systems include both the natural gas and fuel oil handling and firing systems.

Natural gas is supplied from a gas main to the natural gas header used to supply gas to the individual boilers.

The fuel oil handling system consists of an unloading station and fuel oil transfer pumps for the delivery of fuel oil from delivery vehicles to the two 300,000-gallon fuel oil storage tanks. To ensure that the fuel oil can be transferred to the boilers under severe weather conditions, heat tracing is provided on some of the fuel oil lines. In addition, each storage tank is equipped with a fuel oil suction heater. The heater receives steam from the high pressure steam distribution system. Condensate from the heaters is directed to the blowoff tank (Figures B1-8, B1-17, and B1-18).

The fuel oil firing system contains six fuel oil pumps that take suction on the fuel oil storage tanks. The pumps supply fuel to a common header that supplies fuel to all of the boilers. The header pressure is controlled by a pressure control valve that controls the recirculation rate of fuel oil from the supply header back to the storage tanks. To increase the efficiency of the steam atomizing burners, fuel oil heaters are provided just upstream of the burners. The steam is supplied

to the heaters and for fuel oil atomization from the high pressure steam distribution system (see Figures B1-8 and B1-18).

Refrigeration Systems

The refrigeration systems include the condenser water, chiller, and chilled water distribution systems.

Condenser Water System

The function of the condenser water system is to provide cooling water to the refrigeration plant chillers for removing heat contained in the refrigerant (see Figures B1-3 and B1-14).

The condenser water source is the Potomac River via the lagoon adjoining Columbia Island. Water from the river enters the east and west condenser water "sumps" after passing through a bar screen and sluice gates located at the lagoon. The design inlet condenser water temperature for the chillers is 82°F.[1]

The water passes through traveling screens as it enters the sumps. Five condenser water pumps take suction on each of the two sumps (a total of 10 pumps). The water passes through an automatic backwash strainer at the discharge of each pump and then to one of two 54-inch headers from which it is distributed to the chillers. The east and west condenser water headers are cross-connected by a 42-inch line. After passing through the chillers, the water is returned to the river; some of the return water may be directed back to the pump intake pits to control inlet water temperature.

Three screen wash pumps take suction on the condenser water headers. These pumps supply water for washing the traveling screens.

A sump dewatering pump is provided for draining each of the condenser water sumps.

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[1]Temperatures in the lagoon have exceeded the design limit by a few degrees on some occasions (up to about 91°F). A study has been initiated to evaluate the feasibility of adding a second set of intake-outfall lines directly to the Potomac River; these could provide lower temperature water than the existing lines and would allow maintenance to be performed on a routine schedule. Currently, maintenance is performed during a short period around Presidents' Day.

Chiller System

The function of the chiller system is to remove the heat absorbed by the chilled water in the buildings in the system and transfer that heat to the condenser water (see Figures B1-10, B1-13, and B1-15).

The chiller system consists of 10 chillers. Each chiller has a capacity of 3,750 tons and contains a refrigerant compressor, condenser, and evaporator that permit the refrigerant to cool the water passing through the chiller.

The chiller system also includes several supporting subsystems:

- Refrigerant vent and pump-out system, including storage tanks, which allows for the removal and addition of refrigerant to the chillers (see Figure B1-15)
- Refrigerant gas leak detection system that sounds an alarm if refrigerant leaks at the pump-out receivers
- Compressor oil system that lubricates and cools the compressor's journal and thrust bearings and seals the freon from the ambient
- An air purge system that removes noncondensable gases from the chillers.

Chilled Water Distribution System

The function of the chilled water distribution system is to route chilled water to heat exchangers to condition and cool the air in the various buildings on the system. As shown in Figure B1-10, the chilled water distribution system is a closed-loop system.

The system contains 10 chiller loop pumps. Each pump takes suction on one of the two chilled water return manifolds and supplies water to the associated chiller. From the chiller, the cooled water is directed to a common 42-inch chilled water header. Four chilled water distribution pumps take suction on the 42-inch chilled water header. These pumps supply water to the 42-inch distribution header, which supplies chilled water to two 36-inch chilled water supply lines.

Cross-connects are provided between the two condensate return lines and between the two condensate supply lines. In addition, isolation valves at the inlet and discharge of each pump enable the operators to isolate each pump as needed. This configuration allows for additional flexibility in the operation and maintenance of the system.

The chilled water system also includes a makeup system that supplies city water to the system when necessary to maintain normal operating conditions. Expansion tanks provided on each of the chilled water return manifolds

accommodate the thermal expansion of the water while maintaining an over pressure on the system. A chemical feed system provides for the injection of chemicals for corrosion control, and a centrifugal separator provides for the removal of solids from the system.

AUXILIARY SYSTEMS

Auxiliary plant systems include compressed and instrument air; city water; plant services such as communications and heating, ventilation, and air conditioning; and fire protection systems.

Compressed Air System

The compressed air system contains two subsystems: the service air system, which supplies compressed air throughout the plant for operating pneumatic tools and components, and the instrument air system, which supplies compressed air for system control applications (see Figure B1-16).

The service air system consists of three 120 scfm air compressors, two 200 gallon air receivers, two air dryers, and distribution piping and valves. The instrument air system consists of two 50 scfm air compressors, two 120 gallon air receivers, an air dryer, a desiccant air dryer, and distribution piping and valves.

The compressed air system also includes a water cooling system that

- routes water through the aftercoolers to cool the discharge air prior to distribution to the compressed air system, and
- routes water through the compressor water jackets to remove the heat generated during the air compression process.

City Water System

The function of the city water system is to provide water to the various plant operating systems. Three inlet lines, two from the District of Columbia and one from Arlington County, feed the supply header. The header, in turn, supplies water to the condensate system (makeup water), locker rooms, rest room wash, drinking fountains, hot water tanks, and plant wash outlets. The city water system also can supply water, in an emergency, to the chilled water expansion tanks, fire systems, condensate polishers, and water softening station for prefilling the entire treated water system for a plant cold start. This system is located in the basement of the chiller plant.

Plant Services Systems

The function of the plant service systems is to provide support services required for daily plant operations. The plant services include a vacuum system for housekeeping services, a service elevator for transportation, a telephone/intercom system for plant communications, a ventilation and air conditioning system for climate control, and an overhead crane in the refrigeration plant for moving large refrigeration equipment.

Fire Protection System

The fire protection system includes a foam fire system at the fuel oil unloading tank and a standpipe and water sprinkler system throughout the interior of the plant.

SEWAGE SYSTEM

The function of the plant sewage system is to route wastewater from the plant, the Pentagon (services and sanitary services), Arlington Cemetery Visitors Center, and the incinerator to the Arlington city sewers.

The plant sewage system consists of three separate and distinct subsystems: storm water, sanitary water, and plant process waste sewers and incinerator quench water systems (see Figure B1-??). The wastewater system is equipped with intercepting traps that prevent debris and sewage from backing up into the lines. The sanitary waste and plant process waste systems are also equipped with traps that prevent sewer gases from backing into the lines. Also, the plant's sewage system handles wastewater and ash pit water from the incinerator building, located west of the plant.

The ground water system is directly connected to the city storm sewers that empty into the Potomac River. Sanitary sewage and processed wastewater from the plant and incinerator enter the sewage pumping station and then is pumped into the Arlington sanitary sewage system to be treated at its sewage treatment plant.

ELECTRICAL SYSTEMS

The electrical systems consist of high and low voltage alternating current (AC) systems and a low voltage direct current (DC) system.

High Voltage System

The NHRP high voltage system includes the 13.8- and 4.16-kV AC distribution systems. Power is supplied to these systems from three 13.8-kV Virginia Power feeders located in Switchhouse No. 1. Power is distributed from the 13.8-kV bus in Switchhouse No. 1 as follows (See Figure B1-19):

- Three 13.8-kV feeders to the Pentagon
- Three 13.8/4.16-kV transformers supplying the three 4.16-kV busses used to supply most of the NHRP electrical requirements
- 13.8/2.3-kV transformers supplying the 2.3-kV bus.

All high voltage switchgear is controlled locally at the switchgear and is provided with emergency control power by a 125-V DC battery system.

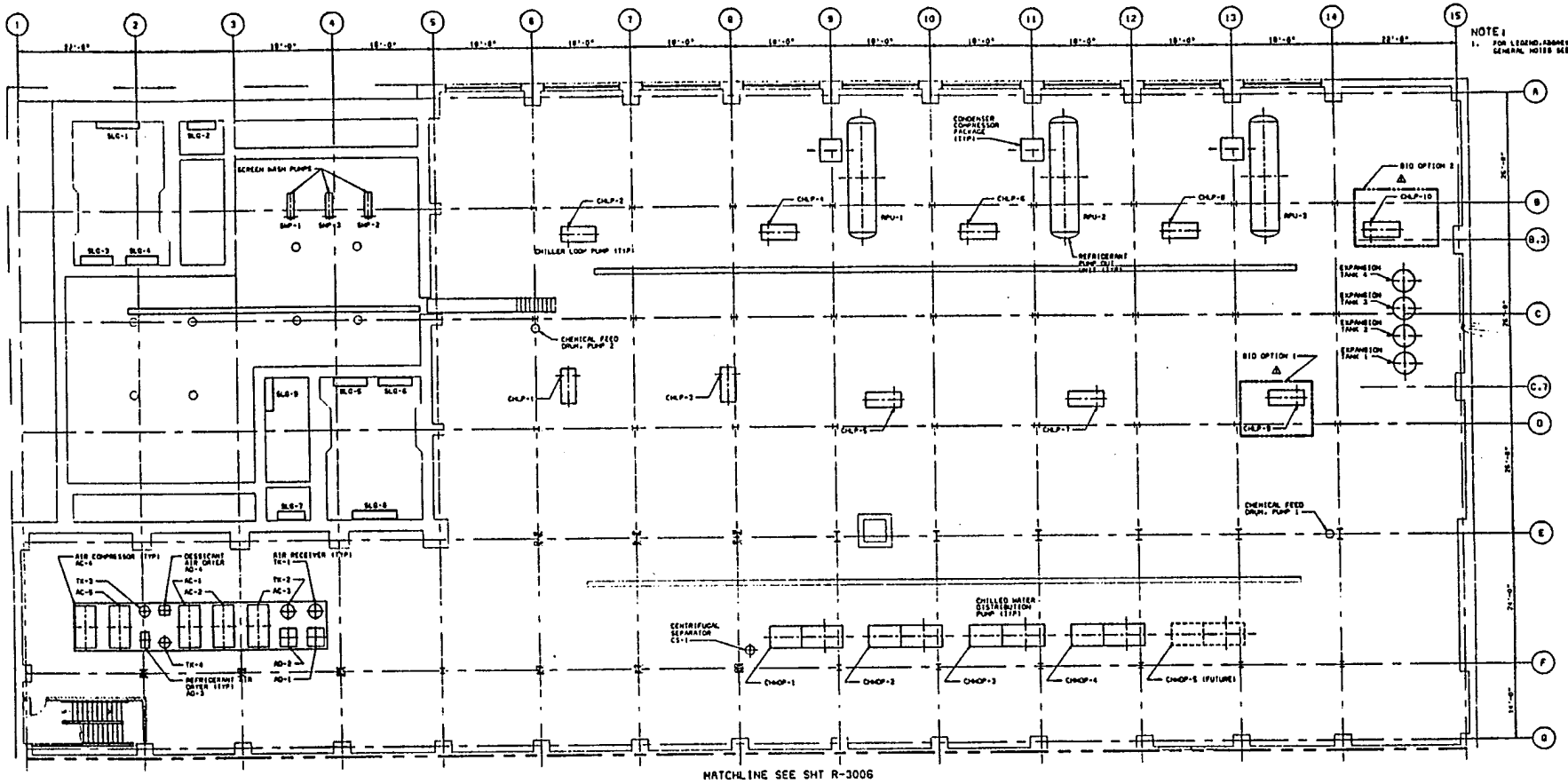
The 4,160-V switchgear is located on the first floor of the refrigeration plant.

Low Voltage System

The low voltage system (480/208/120-V AC and 125-V DC) receives power from the high voltage system and, after transforming it down to the required voltage, supplies all of the plant's lower voltage loads. The low voltage system is used for operating and controlling all of the heating and refrigeration plant auxiliary electrical loads and for lighting.

The loads supplied by the low voltage system are powered from switchboards, motor control centers, and power panels located on the first floor of the refrigeration plant. All voltage to these panels and boards must be transformed down from a higher value of supply voltage by means of various transformers rated at specific voltages.

The DC system converts the low voltage AC supply to DC. The DC power is used to operate the high voltage switchgear and to charge the battery banks. The DC system offers an uninterrupted source of control voltage for the safe operation of the high voltage switchgear. There are two DC voltage systems.



BASEMENT PLAN

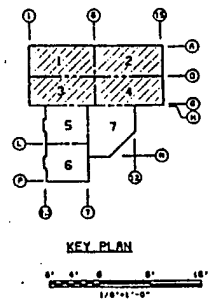


Figure B-1

REV	DATE	DESCRIPTION	BY
1	7/6/92	AMENDMENT NO. 10	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

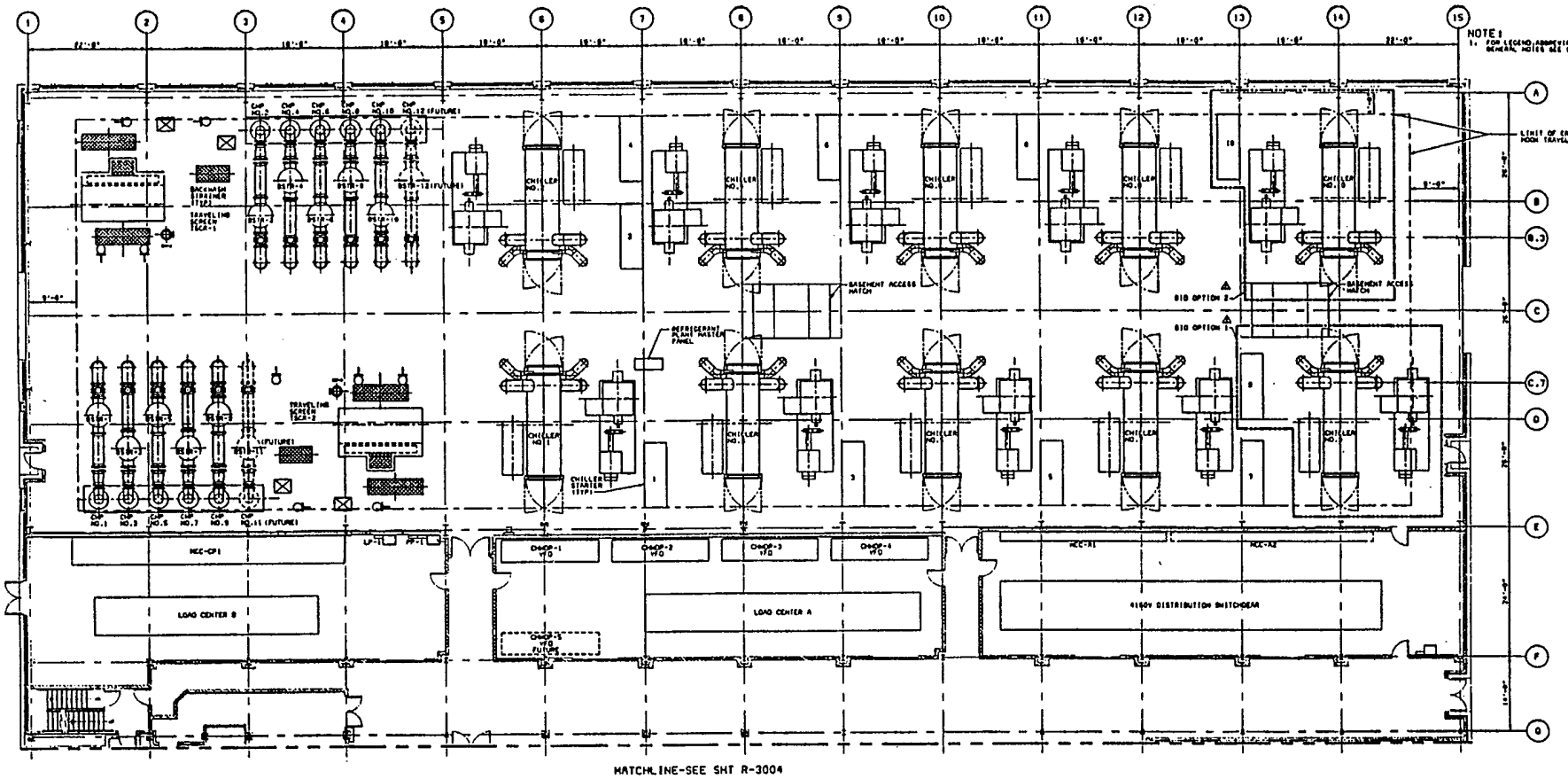
PLANT ARRANGEMENT
REFR PLANT BSMT FLOOR

BLACK & VEATCH

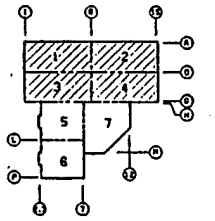
DRAWING NUMBER: E-821-90-46 | PLATE: 203

SCALE: 1/8"=1'-0" | DATE: 21 FEB 92 | SHEET R-3001

COD. 17182-900-CPA-ACF002



FIRST FLOOR PLAN



KEY PLAN

Figure B-2

REV	DATE	DESCRIPTION	BY
1	9502[illegible]	AMENDMENT NO. 10	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

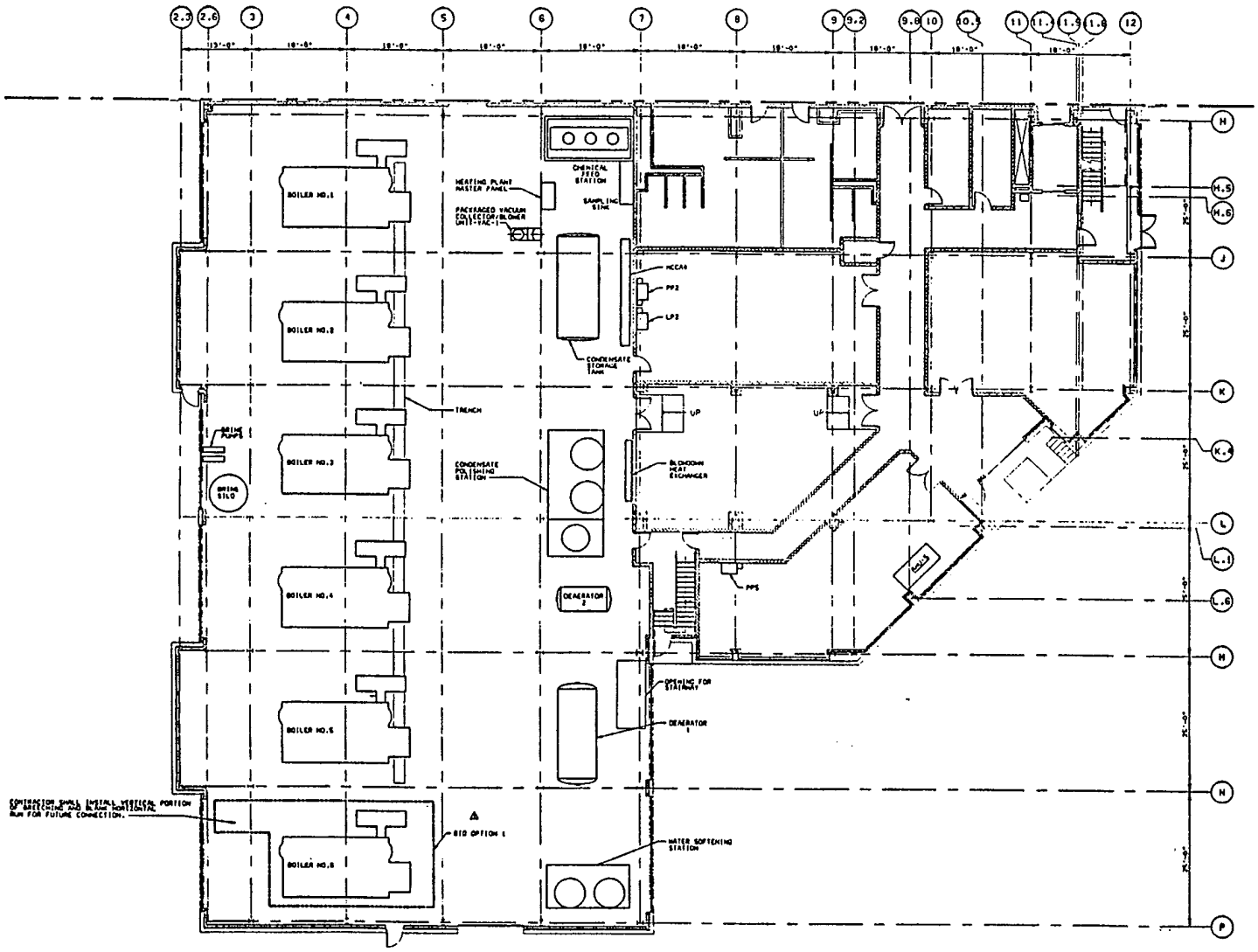
ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

PLANT ARRANGEMENT
REFR PLANT FIRST FLOOR

BLACK & VEATCH	DRAWING NUMBER F-821-90-46	PLATE 204
SCALE: AS NOTED	DATE: 21 FEB 92	SHEET R-3002

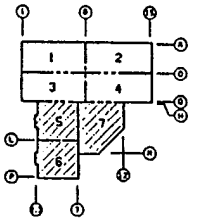
CODE 17182-900-CPA-ACF001



FIRST FLOOR PLAN

NOTES:

1. [illegible]



KEY PLAN

Figure B-3

1	03/07/92	AMENDMENT NO. 10	
NO.	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

PLANT ARRANGEMENT HEATING PLANT/ADMIN AREA FIRST FL

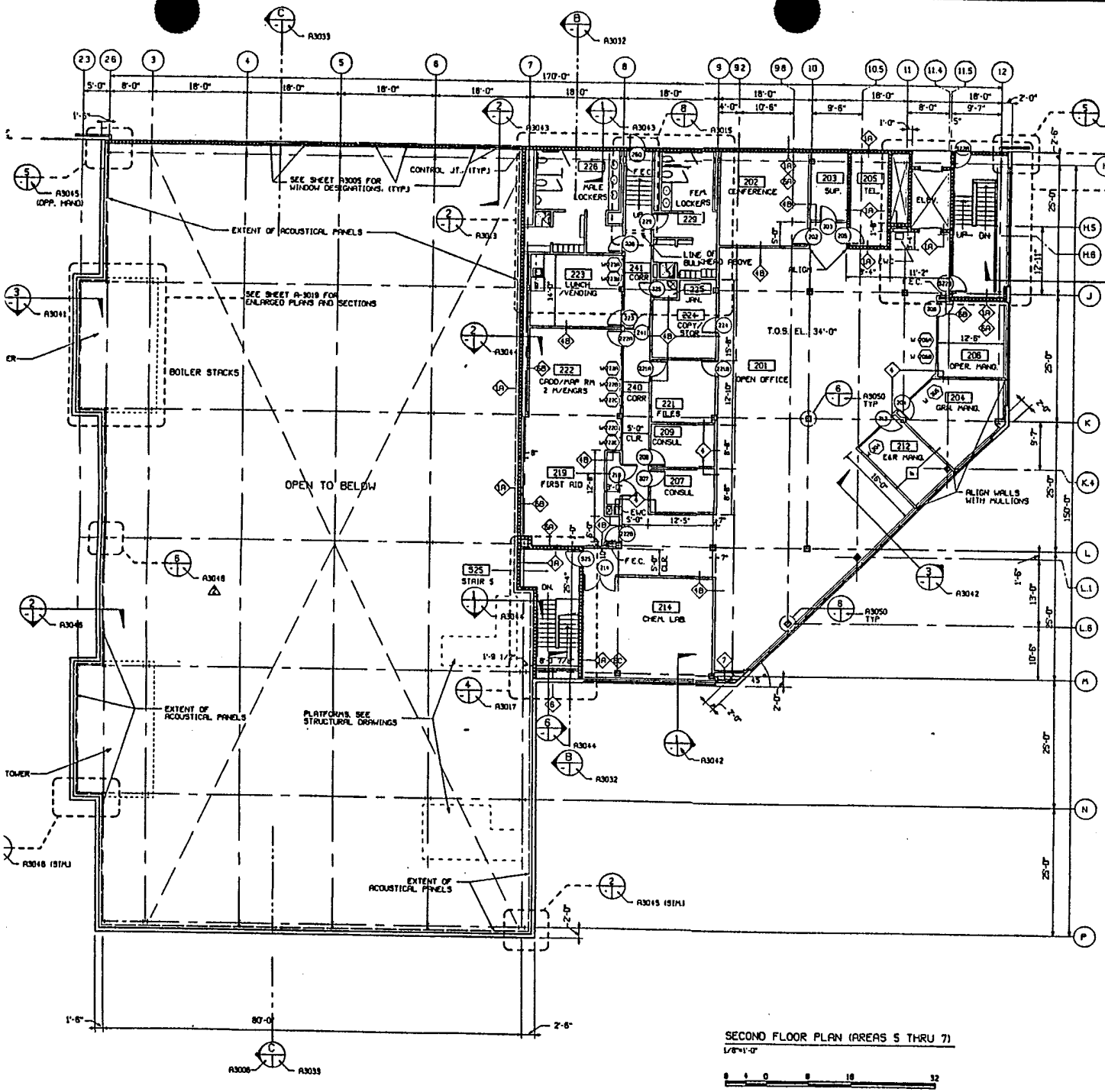
BLACK & VEATCH

DRAWING NUMBER: F-821-90-46

PLATE: 206

SCALE: 1/8"=1'-0" DATE: 21 FEB 92 SHEET R-3004

COD. 17162-800-CPA-ACF611



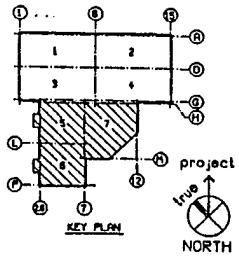
GENERAL NOTES

1. ALL CMU WALLS ARE DIMENSIONED TO FACE OF CMU.
2. ALL PIPING, CONDUIT, ETC. PENETRATIONS THRU FLOORS AND FIRE WALLS SHALL BE FIRESTOPPED.
3. THE CONTRACTOR SHALL COORDINATE THE INSTALLATION OF ALL EMBEDMENTS IN THE CONCRETE SO THEY ARE LOCATED TO PROPERLY INTERFACE WITH ARCHITECTURAL, STRUCTURAL, MECHANICAL, AND ELECTRICAL WORK.
4. ALL SPRINKLER HEADS IN ACOUSTICAL CEILINGS SHALL BE CENTERED IN CEILING TILES.
5. CMU WALLS EXTENDING TO THE STRUCTURE ABOVE SHALL HAVE 1-1/2" JOINTS AT THE TOP OF WALL TO ALLOW FOR DEFLECTION OF THE STRUCTURE. JOINTS SHALL BE FILLED WITH COMPRESSIBLE FILLER, BACKUP ROD, AND SEALANT. PROFILE CLOSURES SHALL BE PROVIDED WHERE WALLS BUTT FLUTED ROOF DECK. FILLER, BACKUP ROD, AND SEALANT SHALL BE FIRE RATED AT FIRE WALLS.
6. EXPANSION JOINTS (EJ) IN CMU WALLS SHALL BE PROVIDED AT THE LOCATIONS INDICATED ON THE DRAWINGS. CONTROL JOINTS (CJ) SHALL BE PROVIDED AT ALL CMU WALL INTERSECTIONS, WHERE CMU ABUTTS CONCRETE CONSTRUCTION OR STEEL COLUMNS, AT ALL OPENINGS (ON ONE SIDE AT OPENINGS UP TO SIX FEET WIDE, BOTH SIDES AT OPENINGS OVER SIX FEET WIDE - SEE STRUCTURAL), AND AT OTHER LOCATIONS INDICATED ON THE DRAWINGS.
7. CMU AROUND STEEL PENETRATIONS THRU WALLS SHALL BE CUT TO THE PROFILE OF THE MEMBER LEAVING A 1-1/2" GAP BELOW THE MEMBER AND A 1/2" GAP ELSEWHERE. GAPS SHALL BE FILLED WITH COMPRESSIBLE FILLER, BACKUP ROD AND SEALANT. FILLER, BACKUP ROD AND SEALANT SHALL BE FIRE RATED FOR PENETRATIONS THRU FIRE WALLS.
8. SEE LOUVER SCHEDULE AND ELEVATIONS FOR PRECAST OPENING SIZES.
9. SEE FIRE PROTECTION DRAWING FOR FIRE EXTINGUISHER LOCATIONS.
10. ALL GYP. BD. PARTITIONS TO BE TYPE (4) UNLESS NOTED OTHERWISE.
11. ALL DIMENSIONS ARE TO FACE OF GYP. BD. PARTITIONS

SYMBOLS

- DENOTES COLUMN WITH SPRAYED ON FIRE PROTECTION FOR TWO HOUR RATING
- DENOTES RATED WALL CONSTRUCTION

Figure B-4



REV	DATE	DESCRIPTION	BY
2	12 JUN 92	REVISED PER AMENDMENT NO 13	CEC
1	APR 92	REVISED PER AMENDMENT NO. 1 (DESCRIPTIVE)	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

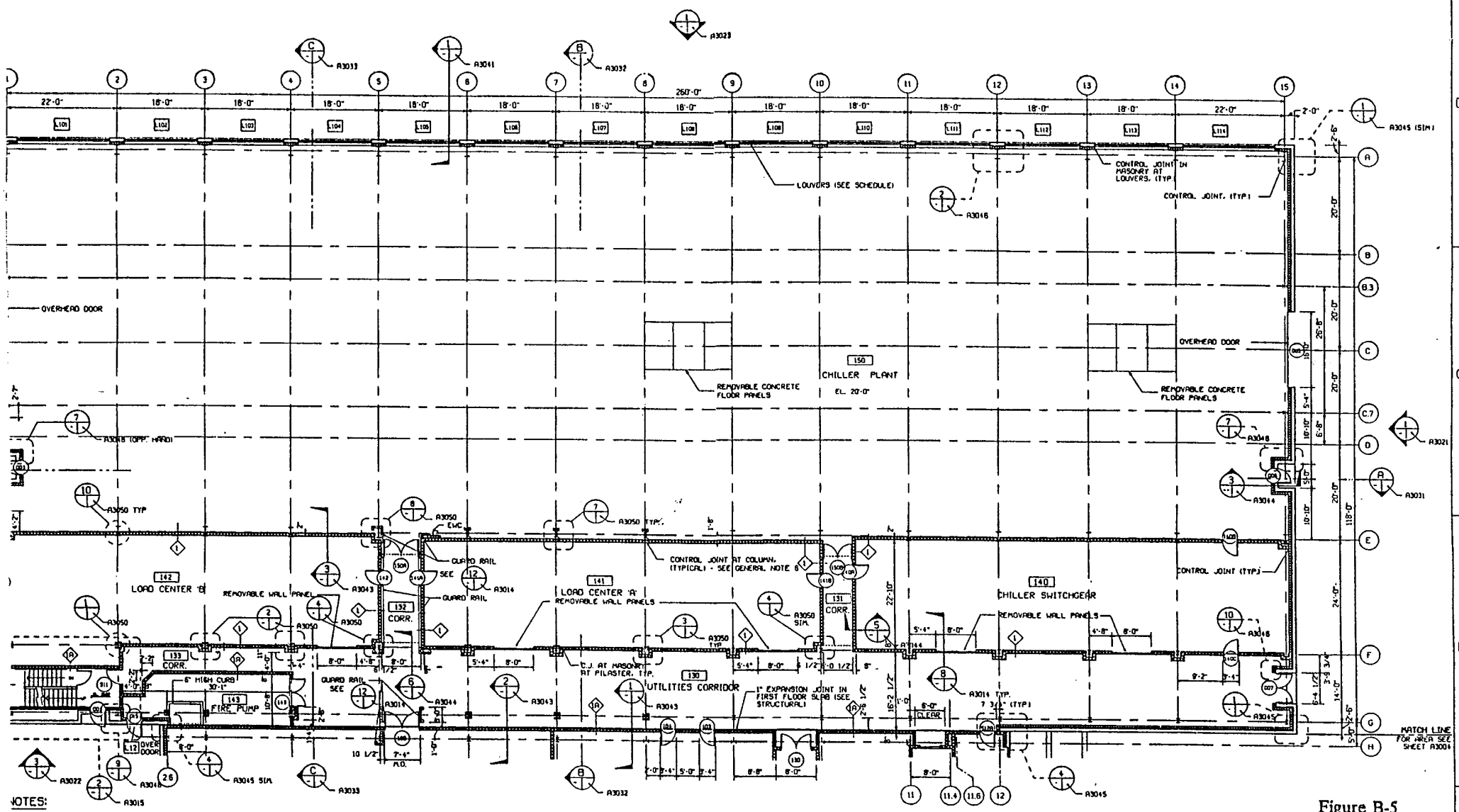
ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

SECOND FLOOR PLAN
AREAS 5 THRU 7

DRAWING NUMBER	PLATE
F-821-90-46	88

SCALE	DATE	SHEET
AS NOTED	21 FEB 92	A-3006



NOTES:

LLS ARE DIMENSIONED TO FACE OF CMU.

CONDUIT, ETC. PENETRATIONS THRU FLOORS AND SHALL BE FIRESTOPPED.

CTOR SHALL COORDINATE THE INSTALLATION OF ALL IN THE CONCRETE SO THEY ARE LOCATED TO PROPERLY ITH ARCHITECTURAL, STRUCTURAL, MECHANICAL, ICAL WORK.

ER HEADS IN ACOUSTICAL CEILINGS SHALL BE CEILING TILES.

EXTENDING TO THE STRUCTURE ABOVE SHALL HAVE S AT THE TOP OF WALL TO ALLOW FOR DEFLECTION UCTURE. JOINTS SHALL BE FILLED WITH COMPRESSIBLE KUP ROD, AND SEALANT. PROFILE CLOSURES SHALL) WHERE WALLS BUTT FLUTED ROOF DECK. FILLER, , AND SEALANT SHALL BE FIRE RATED AT FIRE WALLS.

8. EXPANSION JOINTS (EJ) IN CMU WALLS SHALL BE PROVIDED AT THE LOCATIONS INDICATED ON THE DRAWINGS. CONTROL JOINTS (CJ) SHALL BE PROVIDED AT ALL CMU WALL INTERSECTIONS, WHERE CMU ABUTTS CONCRETE CONSTRUCTION OR STEEL COLUMNS. AT ALL OPENINGS (ON ONE SIDE AT OPENINGS UP TO SIX FEET WIDE, BOTH SIDES AT OPENINGS OVER SIX FEET WIDE - SEE STRUCTIRAL) AND AT OTHER LOCATIONS INDICATED ON THE DRAWINGS.

7. CMU AROUND STEEL PENETRATIONS THRU WALLS SHALL BE CUT TO THE PROFILE OF THE MEMBER LEAVING A 1-1/2" GAP BELOW THE MEMBER AND A 1/2" GAP ELSEWHERE. GAPS SHALL BE FILLED WITH COMPRESSIBLE FILLER, BACKUP ROD AND SEALANT. FILLER, BACKUP ROD AND SEALANT SHALL BE FIRE RATED FOR PENETRATIONS THRU FIRE WALLS.

8. SEE LOUVER SCHEDULE AND ELEVATIONS FOR PRECAST OPENING SIZES.

9. SEE FIRE PROTECTION DRAWINGS FOR FIRE EXTINGUISHER LOCATIONS.

10. FOR FLOOR DRAINS AND SLOPES SEE STRUCTURAL/PLUMBING.

SYMBOLS

DENOTES COLUMN W/SPRAYED ON FIRE PROTECTION FOR TWO HOUR RATING

DENOTES RATED WALL CONSTRUCTION

FIRST FLOOR PLAN (AREAS 1 THRU 4)

1/8"=1'-0"

8 4 0 8 16 32

KEY PLAN

NORTH

Figure B-5

REV	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

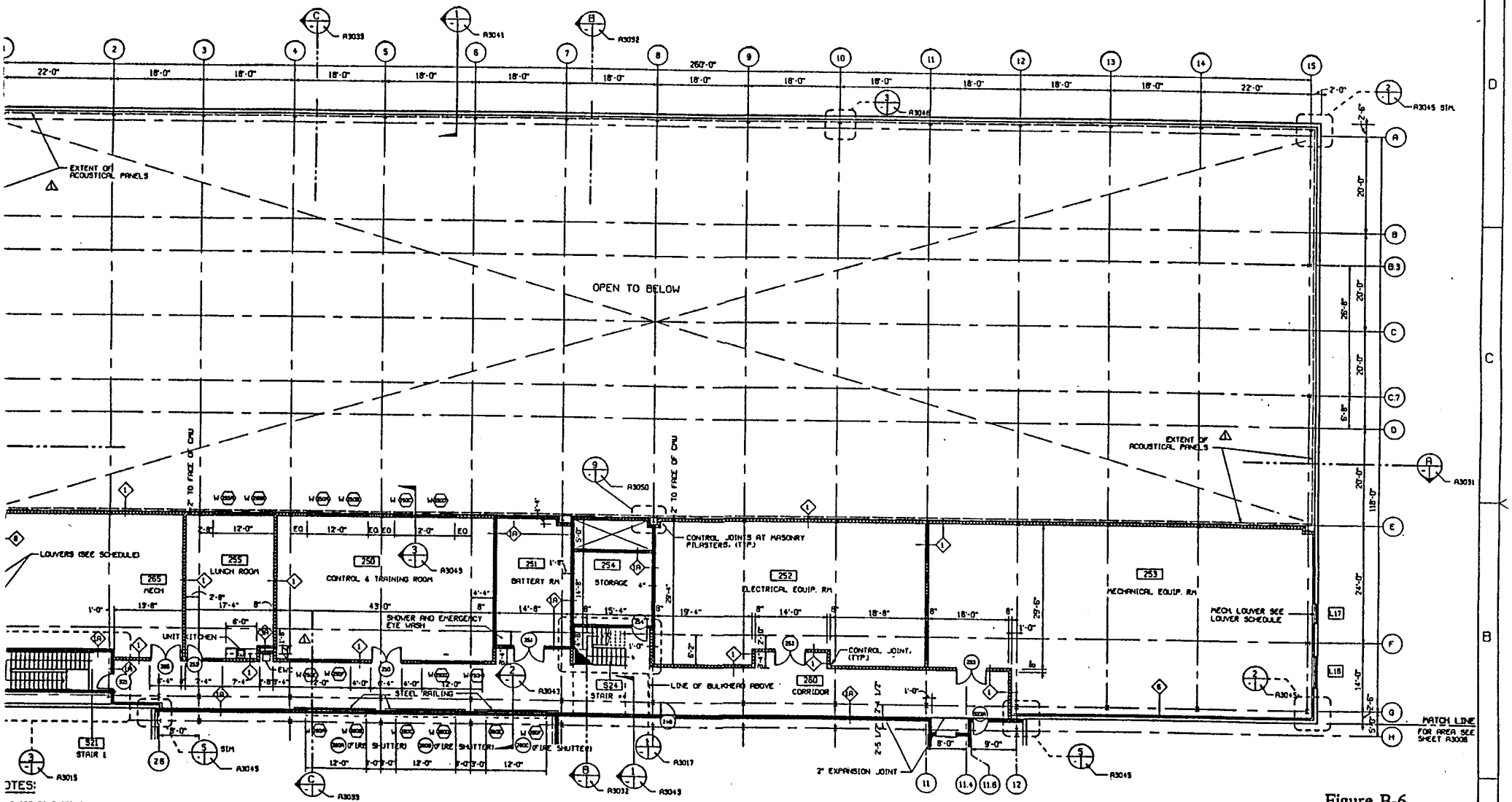
ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

FIRST FLOOR PLAN
AREAS 1 THRU 4

BRYANT AND BRYANT — DRAWING NUMBER F-821-90-46 — PLATE 85

SCALE AS NOTED — DATE FEB 92 — SHEET A-3003



OTES:

LS ARE DIMENSIONED TO FACE OF CMU.

ONDUIT, ETC. PENETRATIONS THRU FLOORS AND SHALL BE FIRESTOPPED.

TOR SHALL COORDINATE THE INSTALLATION OF ALL IN THE CONCRETE SO THEY ARE LOCATED TO PROPERLY TH ARCHITECTURAL, STRUCTURAL, MECHANICAL, AL WORK.

R HEADS IN ACOUSTICAL CEILINGS SHALL BE CEILING TILES.

XTENDING TO THE STRUCTURE ABOVE SHALL HAVE AT THE TOP OF WALL TO ALLOW FOR DEFLECTION CTURE. JOINTS SHALL BE FILLED WITH COMPRESSIBLE UP ROD, AND SEALANT. PROFILE CLOSURES SHALL WHERE WALLS BUTT FLUTED ROOF DECK. FILLER, AND SEALANT SHALL BE FIRE RATED AT FIRE WALLS.

6. EXPANSION JOINTS (EJ) IN CMU WALLS SHALL BE PROVIDED AT THE LOCATIONS INDICATED ON THE DRAWINGS. CONTROL JOINTS (CJ) SHALL BE PROVIDED AT ALL CMU WALL INTERSECTIONS, WHERE CMU ABUTTS CONCRETE CONSTRUCTION OR STEEL COLUMNS, AT ALL OPENINGS (ON ONE SIDE AT OPENINGS UP TO SIX FEET WIDE, BOTH SIDES AT OPENINGS OVER SIX FEET WIDE - SEE STRUCTURAL) AND AT OTHER LOCATIONS INDICATED ON THE DRAWINGS.

7. CMU AROUND STEEL PENETRATIONS THRU WALLS SHALL BE CUT TO THE PROFILE OF THE MEMBER LEAVING A 1-1/2" GAP BELOW THE MEMBER AND A 1/2" GAP ELSEWHERE. GAPS SHALL BE FILLED WITH COMPRESSIBLE FILLER, BACKUP ROD AND SEALANT. FILLER, BACKUP ROD AND SEALANT SHALL BE FIRE RATED FOR PENETRATIONS THRU FIRE WALLS.

8. SEE LOUVER SCHEDULE AND ELEVATIONS FOR PRECAST OPENING SIZES.

9. SEE FIRE PROTECTION DRAWINGS FOR FIRE EXTINGUISHER LOCATIONS.

SYMBOLS

DENOTES COLUMN W/SPRAYED ON FIRE PROTECTION FOR TWO HOUR RATING

DENOTES RATED WALL CONSTRUCTION

SECOND FLOOR PLAN (AREAS 1 THRU 4)

1/8"=1'-0"

0 4 0 8 16 32

KEY PLAN

NORTH

Figure B-6

REV	DATE	DESCRIPTION	BY
1	13 MAY 92	REVISED PER AMENDMENT NO. 0007	BB

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

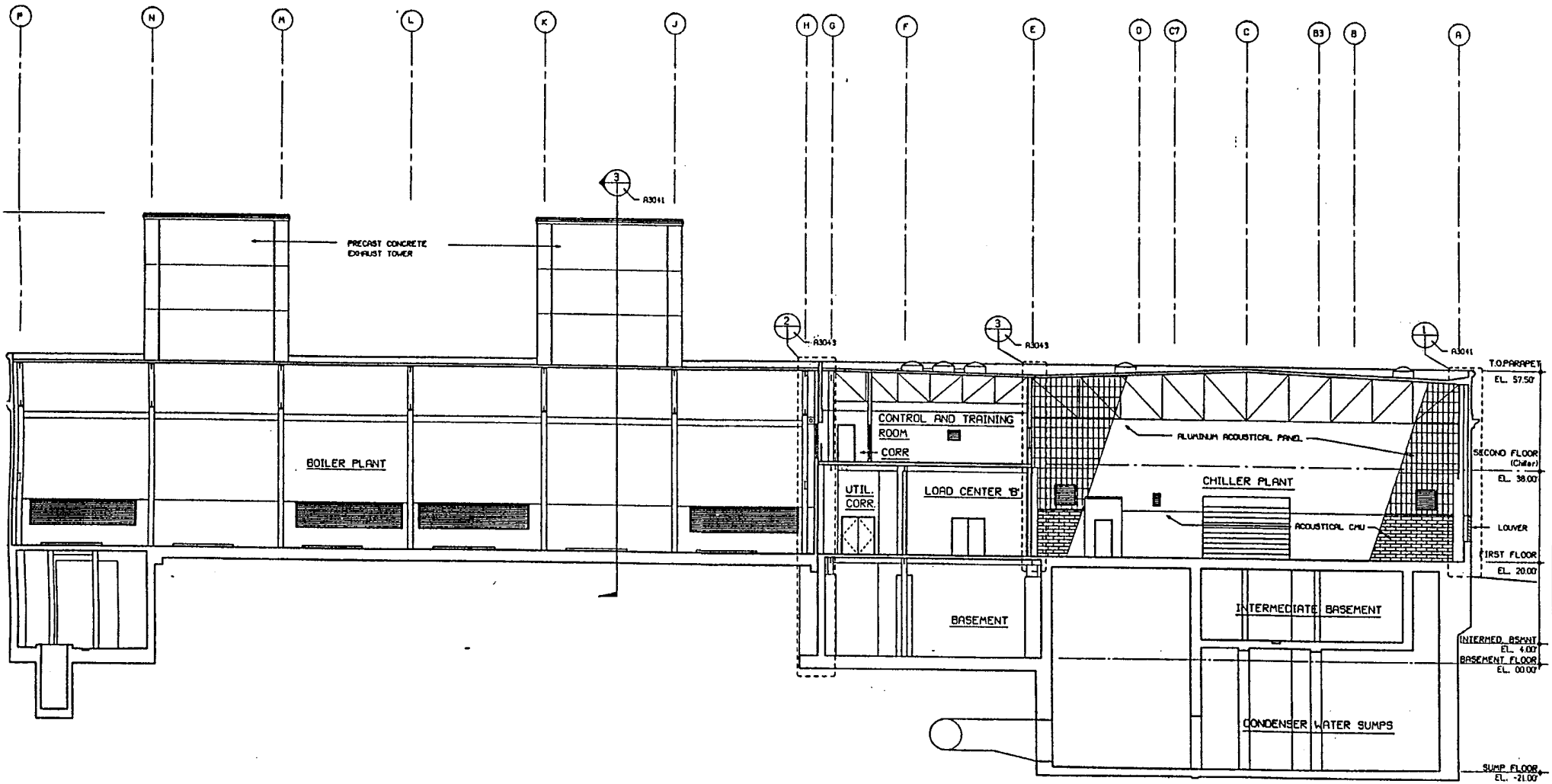
ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

SECOND FLOOR PLAN
AREAS 1 THRU 4

DRAWING NUMBER: F-821-90-46 | PLATE: 87

SCALE: AS NOTED | DATED: 21 FEB 92 | SHEET: A-3005



SECTION C-C
1/8" = 1'-0"

8 4 0 8 16 32

Figure B-7

REV	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

BUILDING SECTION C-C

	DRAWING NUMBER	PLATE
	F-821-90-46	109

SCALE: AS NOTED | FEB 91 | SHEET A-3033

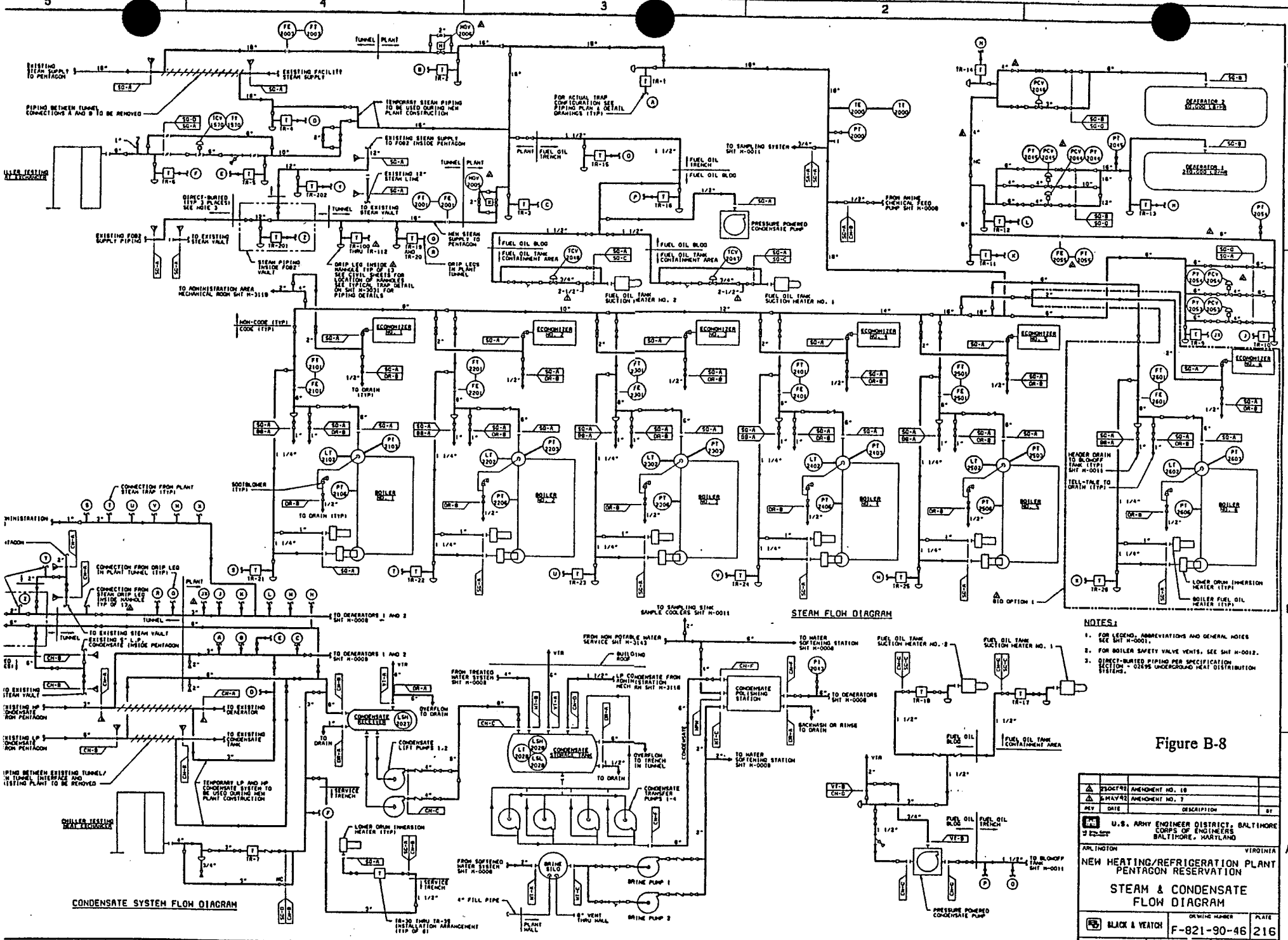


Figure B-8

2	25OCT92	AMENDMENT NO. 10	
1	6MAY92	AMENDMENT NO. 7	
REV	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

STEAM & CONDENSATE
FLOW DIAGRAM

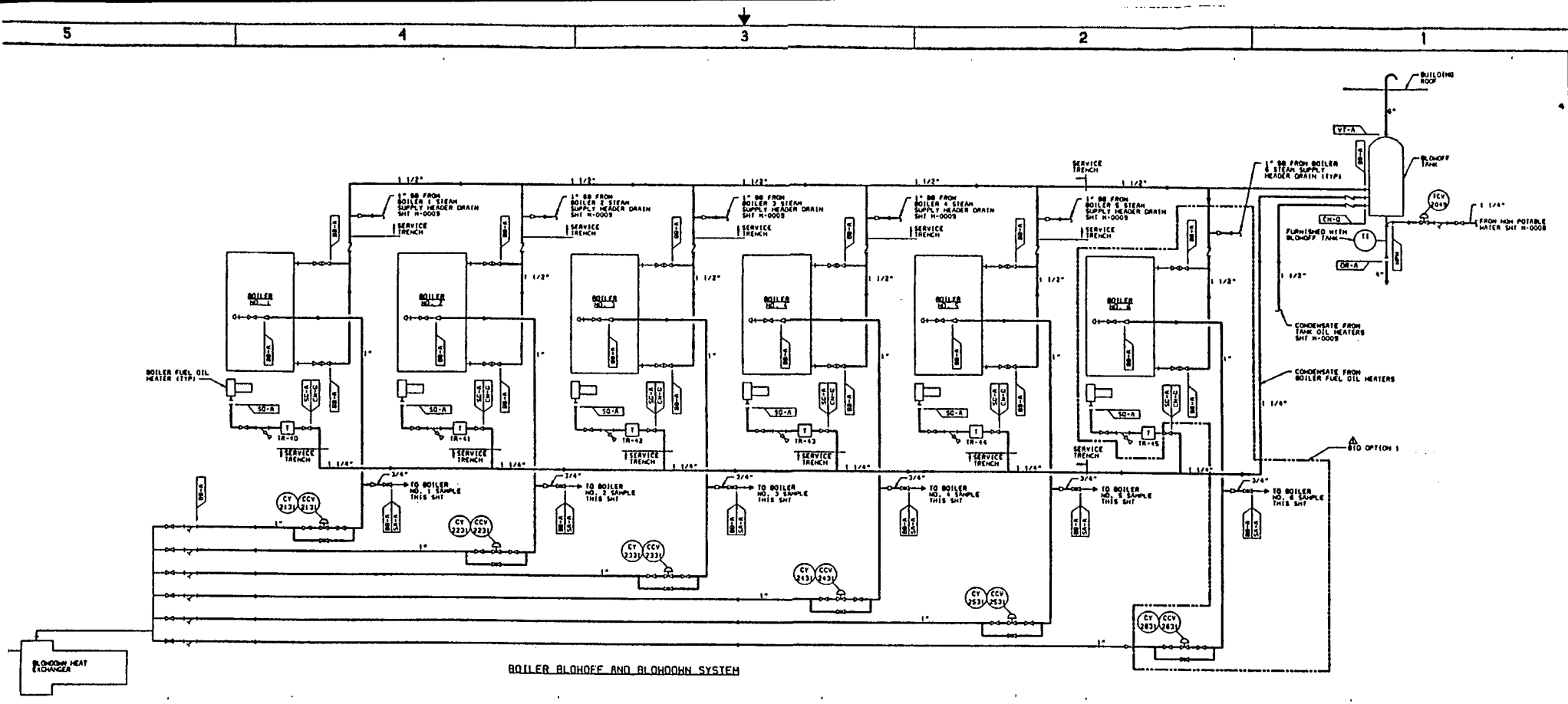
BLACK & VEATCH

DRAWING NUMBER F-821-90-46

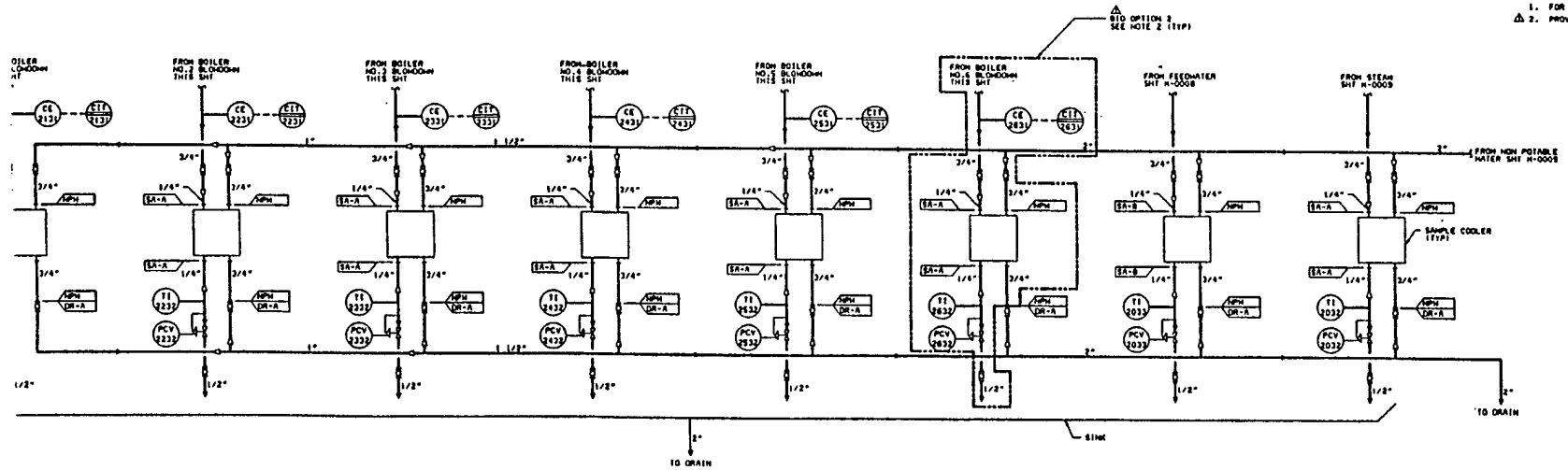
PLATE 216

SCALE: NONE DATE: 21 FEB 92 SHEET M-0009

CCD. 17182-900-CPI-ACF004



BOILER BLOWOFF AND BLOWDOWN SYSTEM



SAMPLING SINK

NOTES:

1. FOR LEGEND, ABBREVIATIONS AND GENERAL NOTES SEE SHT M-0001.
2. PROVIDE VALVES AND BLIND FLANGES AT ALL BID OPTION INTERFACES.

Figure B-9

REV	DATE	DESCRIPTION	BY
A	15 OCT 92	AMENDMENT NO. 18	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

BOILER BLOWOFF & BLOWDOWN SAMPLING SYS. FLOW DIAGRAM

BLACK & VEATCH

DRAWING NUMBER: F-821-90-46

PLATE: 218

SCALE: NONE

DATE: FEB 92

SHEET M-0011

COD. 17102-90G-EP1-ACF020

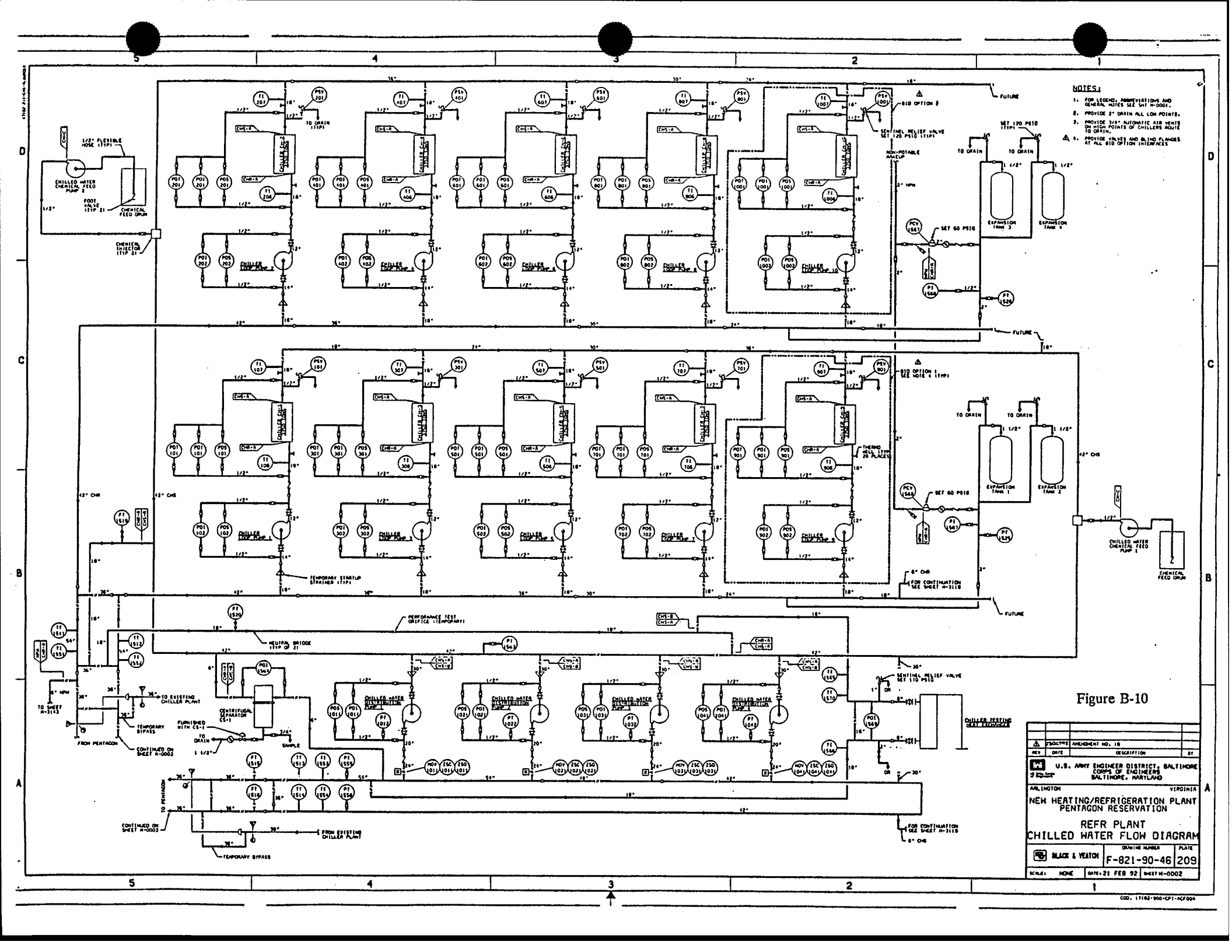


Figure B-10

REV	DATE	DESCRIPTION	BY
2	2SEP92	AMENDMENT NO. 18	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

REFR PLANT
CHILLED WATER FLOW DIAGRAM

BLACK & VEATCH

DRAWING NUMBER	PLATE
F-821-90-46	209

SCALE: NONE | DATE: 21 FEB 92 | SHEET M-0002

COD. 11102-900-CP1-ACF004

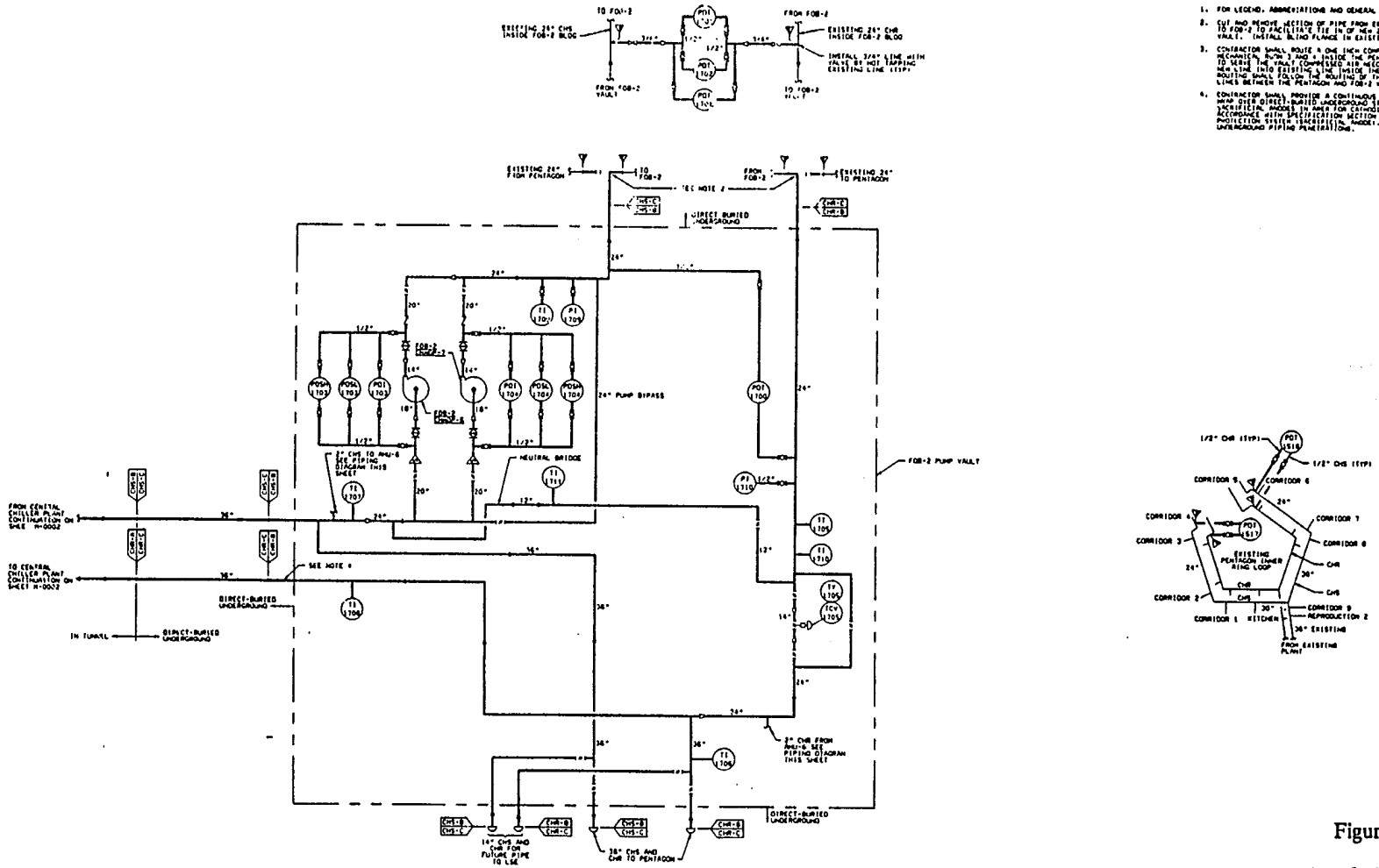


Figure B-11

See Add #18, Item 17
Revised with sketches SK 36 and 37 dated Oct 23 1992

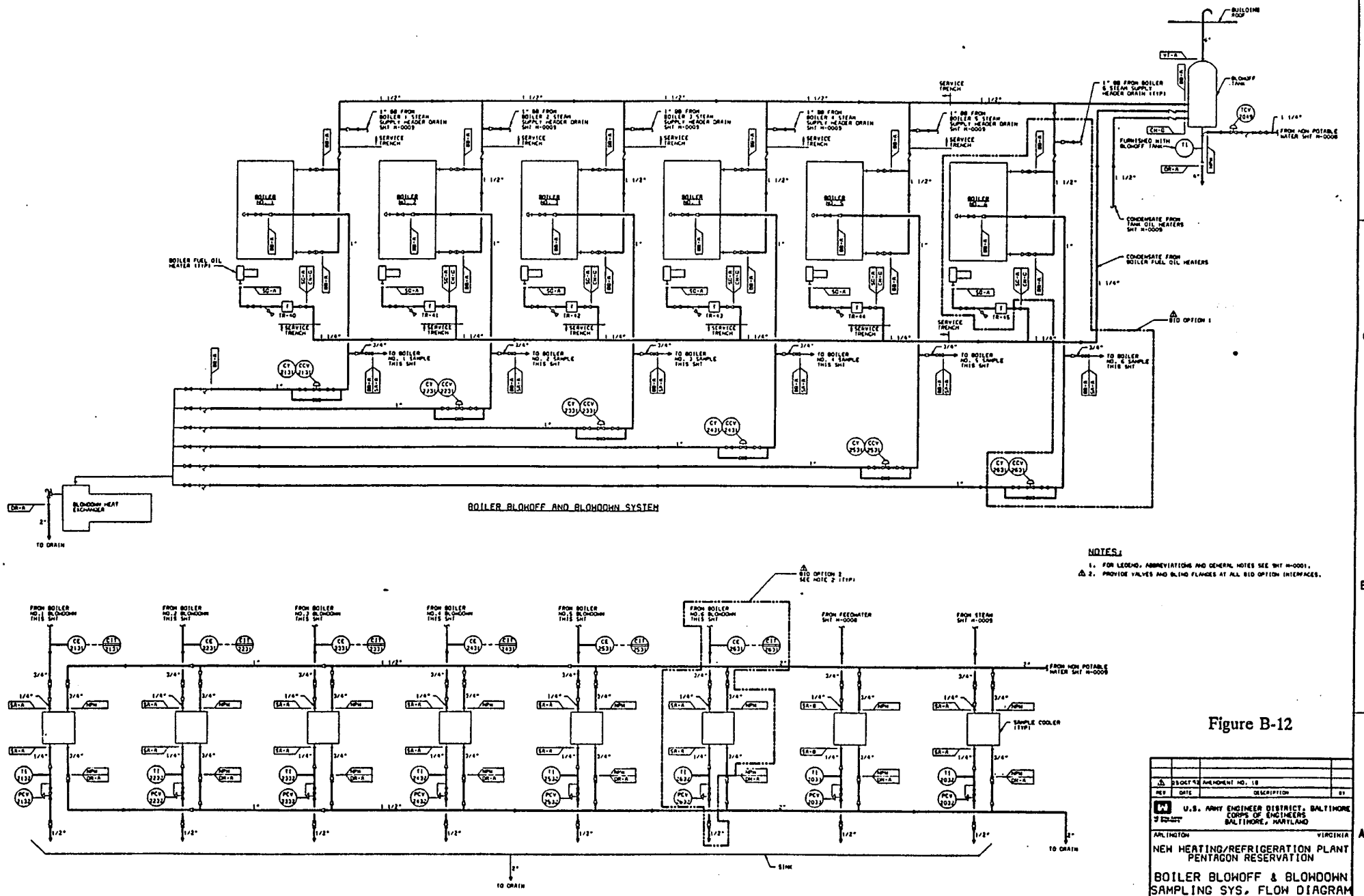
REV	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

...ING/REFRIGERATION PLANT
...INGTON RESERVATION
CHI... ...ER DISTRIBUTION
... DIAGRAM

DRAWING NUMBER	PLATE
F-821-90-46	210

BLACK & VEATCH
21 FEB 92
SHEET M-0003



NOTES:

1. FOR LEGEND, ABBREVIATIONS AND GENERAL NOTES SEE SHT M-0001.
2. PROVIDE VALVES AND BLIND FLANGES AT ALL BID OPTION INTERFACES.

Figure B-12

REV	DATE	DESCRIPTION	BY
1	25OCT92	AMENDMENT NO. 18	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

BOILER BLOWOFF & BLOWDOWN SAMPLING SYS. FLOW DIAGRAM

BLACK & VEATCH

DRAWING NUMBER: F-821-90-46

PLATE: 218

SCALE: NONE

DATE: 21 FEB 92

SHEET M-0011

COD. 17162-900-CP1-ACF020

NOTES:

1. FOR LEGEND, ABBREVIATIONS AND GENERAL NOTES SEE SHT M-0001.
2. FLANGED SPOOL PIECE FOR CHILLER PERFORMANCE TEST (TYP FOR 10 CHILLERS).
3. PROVIDE 2" AUTOMATIC AIR VENT VALVE ON HIGH POINT OF ALL CHILLERS ROUTE TO DRAIN.
4. PROVIDE VALVES AND BLIND FLANGES AT ALL BID OPTION INTERFACES.

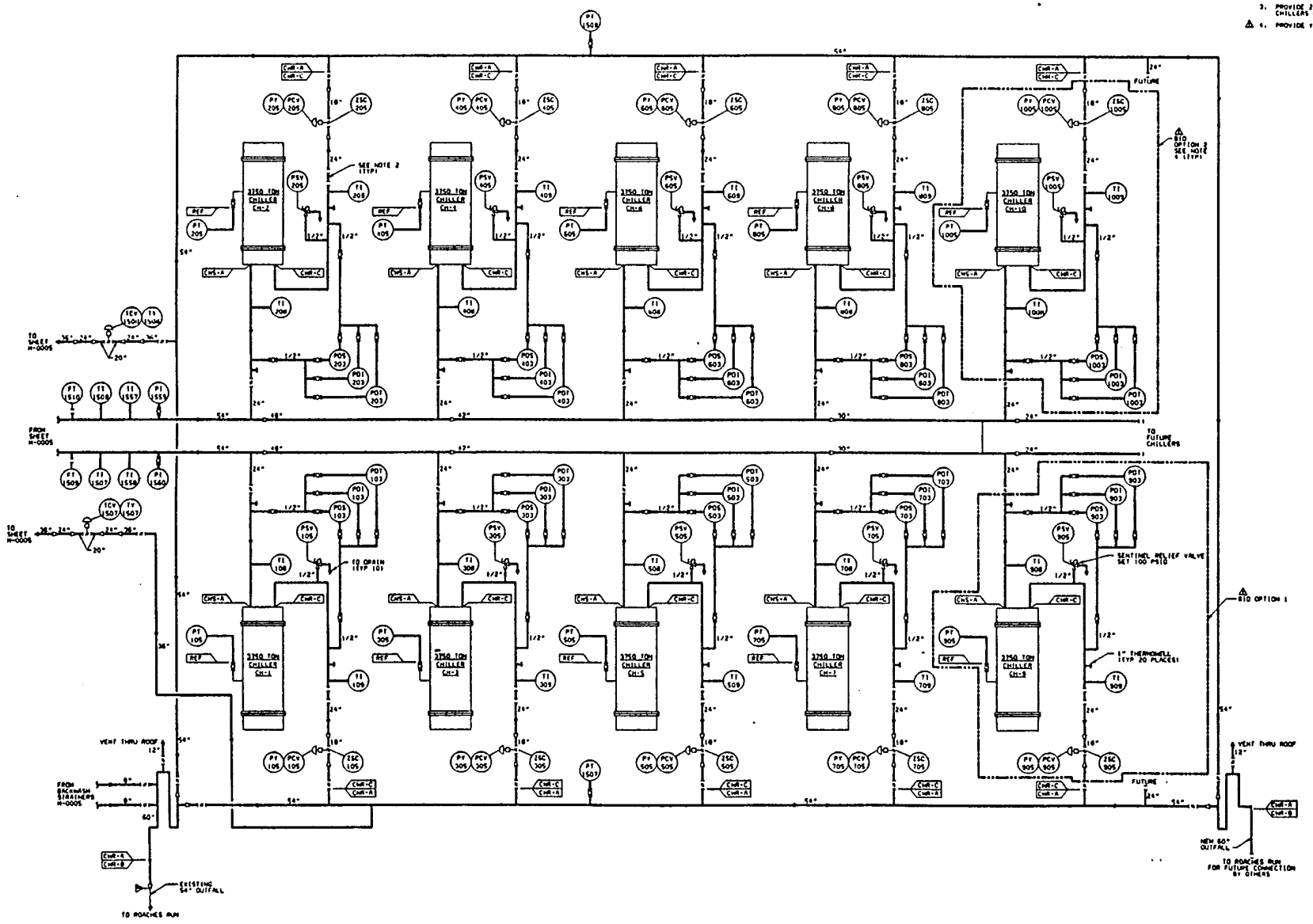


Figure B-13

REV	DATE	DESCRIPTION	BY
A	23OCT91	AMENDMENT NO. 10	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

REFR PLANT CONDENSER WATER FLOW DIAGRAM

BLACK & VEATCH

DRAWING NUMBER F-821-90-46

PLATE 211

SCALE: NONE DATE: 21 FEB 92 SHEET M-0004

COD. 11182-900-CPI-ACF009

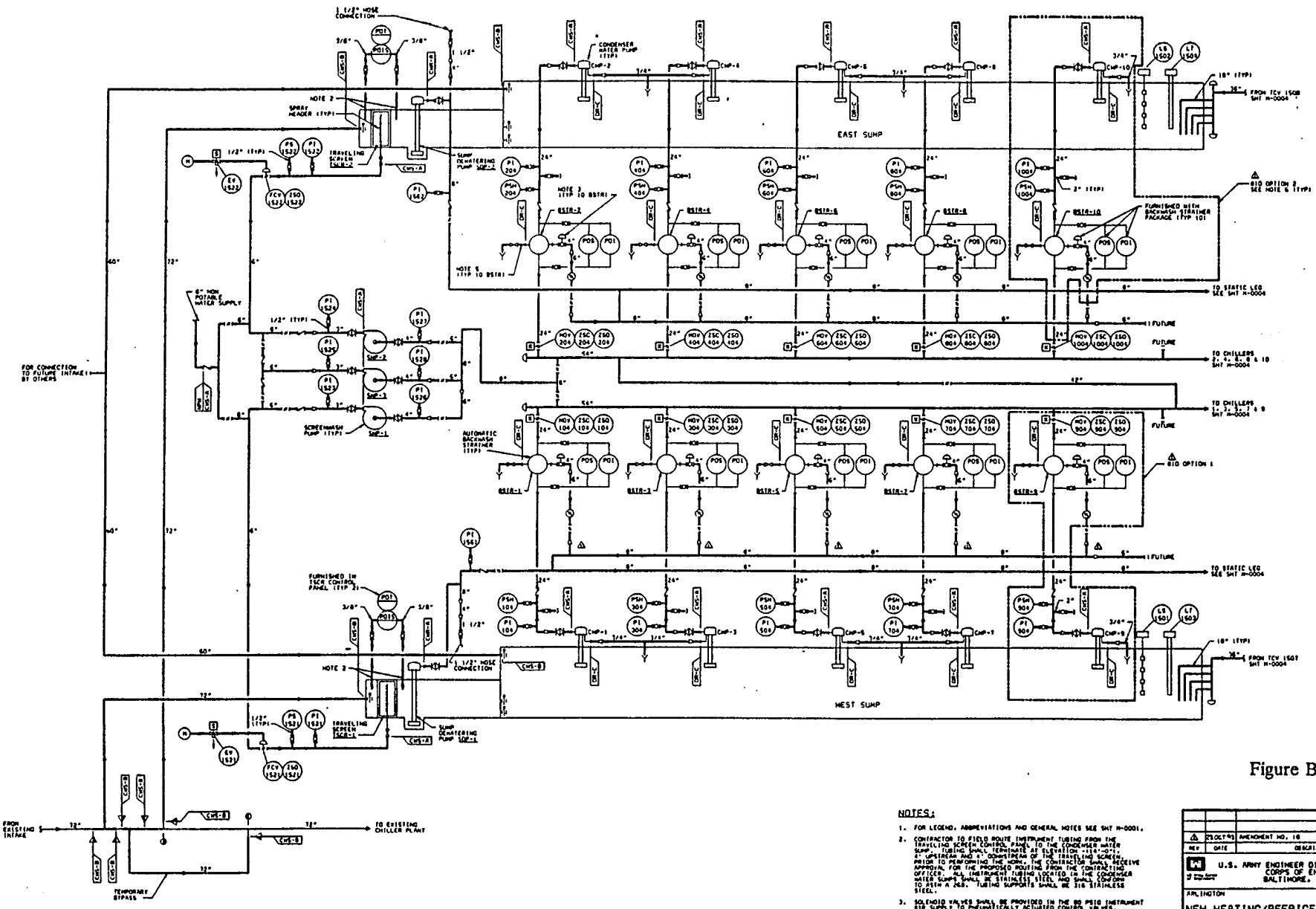


Figure B-14

NOTES:

1. FOR LEGEND, ABBREVIATIONS AND GENERAL NOTES SEE SHT M-0001.
2. CONTRACTOR TO FIELD ROUTE INSTRUMENT TUBING FROM THE TRAVELING SCREEN CONTROL PANEL TO THE CONDENSER WATER SUMP. TUBING SHALL TERMINATE AT ELEVATION -114'-0"±, 4' UPSTREAM AND 4' DOWNSTREAM OF THE TRAVELING SCREEN. PRIOR TO PERFORMING THE WORK, THE CONTRACTOR SHALL RECEIVE APPROVAL FOR THE PROPOSED ROUTING FROM THE CONTRACTING OFFICER. ALL INSTRUMENT TUBING LOCATED IN THE CONDENSER WATER SUMPS SHALL BE STAINLESS STEEL AND SHALL CONFORM TO ASTM A 269. TUBE SUPPORTS SHALL BE 316 STAINLESS STEEL.
3. SOLENOID VALVES SHALL BE PROVIDED IN THE 80 PSIG INSTRUMENT AIR SUPPLY TO PNEUMATICALLY ACTUATED CONTROL VALVES. SOLENOID VALVES SHALL BE IDENTICAL TO EV-521 SHOWN ON THIS DRAWING, AND SPECIFIED IN SECTION 15901.
4. INSTRUMENTATION DEVICES WITHOUT IDENTIFICATION NUMBERS SHALL BE PROVIDED WITH THE PACKAGED EQUIPMENT.
5. PIPING SHALL BE SAME SIZE AS EQUIPMENT DRAIN CONNECTION, BUT NOT LESS THAN 2 INCH. CONTRACTOR SHALL FIELD ROUTE TO NEAREST BELL UP DRAIN.
6. PROVIDE VALVES AND BLIND FLANGES AT ALL BID OPTION INTERFACES.

NO	DATE	DESCRIPTION	BY
1	21 OCT 92	AMENDMENT NO. 10	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

CONDENSER WATER SUPPLY
FLOW DIAGRAM

BLACK & VEATCH | DRAWING NUMBER F-821-90-46 | PLATE 212

SCALE: NONE | DATE: 21 FEB 92 | SHEET M-0005

COD. 17102-900-CF1-ACF024

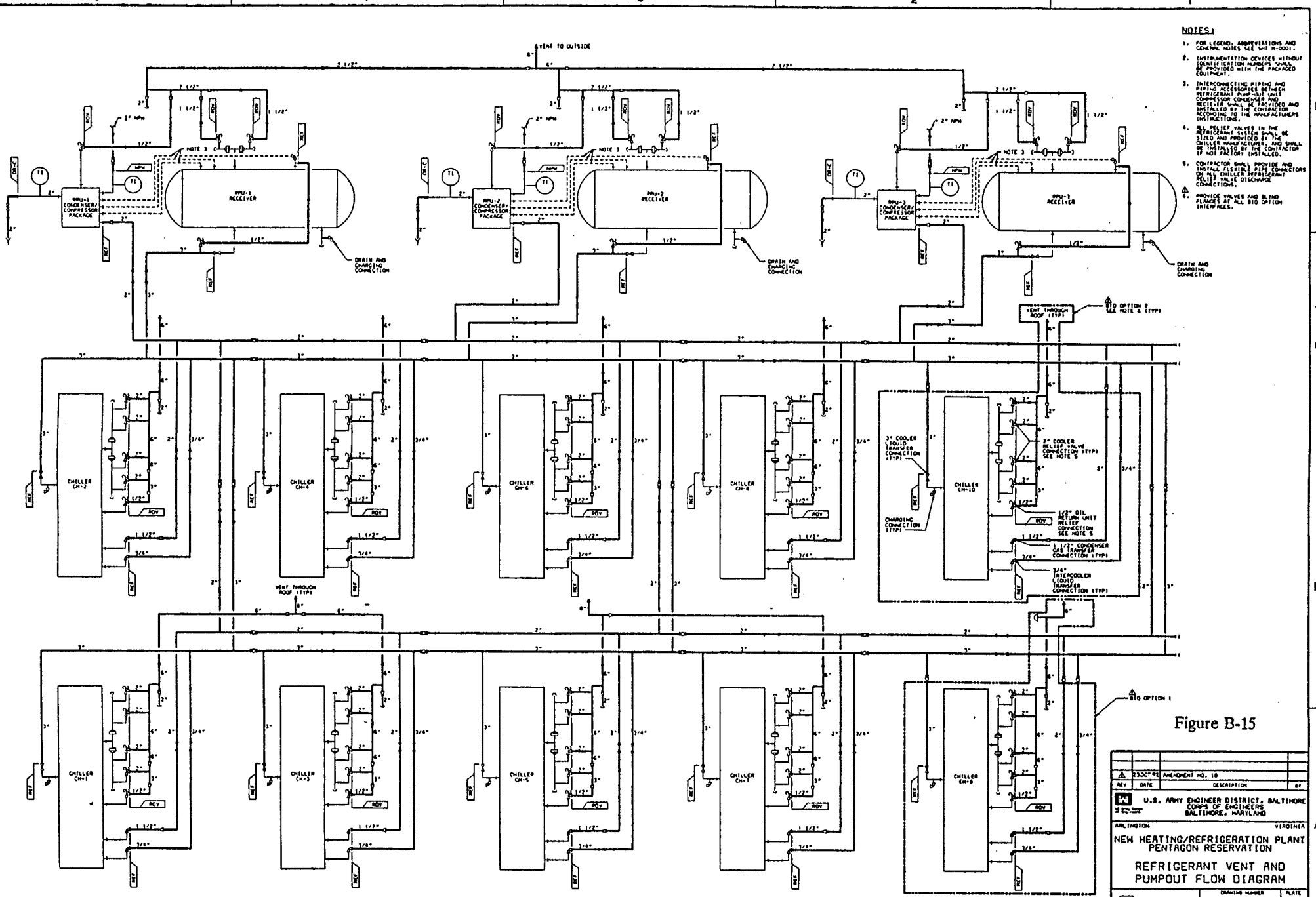


Figure B-15

REV	DATE	DESCRIPTION	BY
1	23OCT92	AMENDMENT NO. 10	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

REFRIGERANT VENT AND PUMPOUT FLOW DIAGRAM

BLACK & VEATCH

DRAWING NUMBER: F-821-90-46

PLATE: 213

SCALE: NONE

DATE: 21 FEB 92

SHEET M-0008

COD. 17182-900-CP1-ACF022

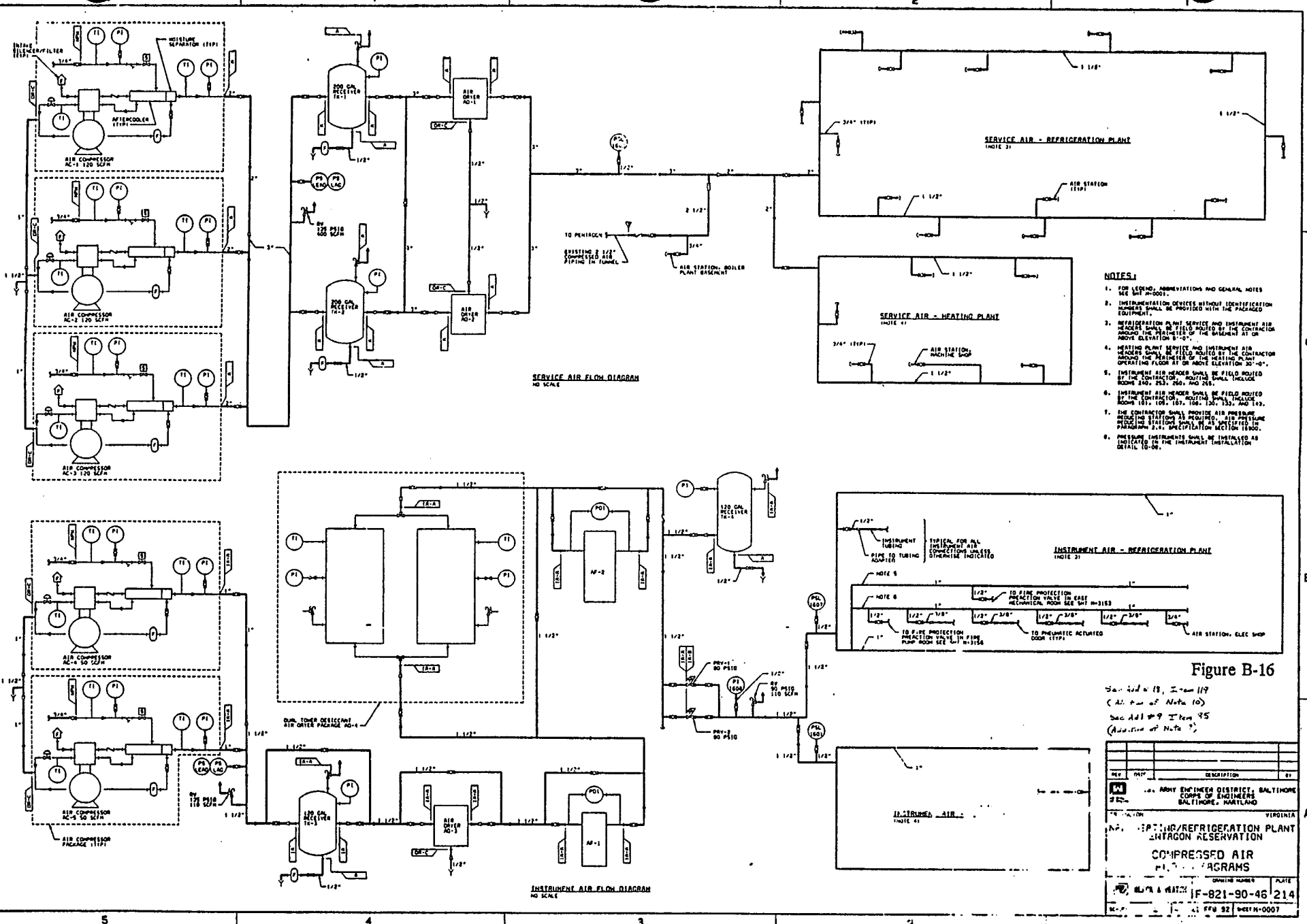
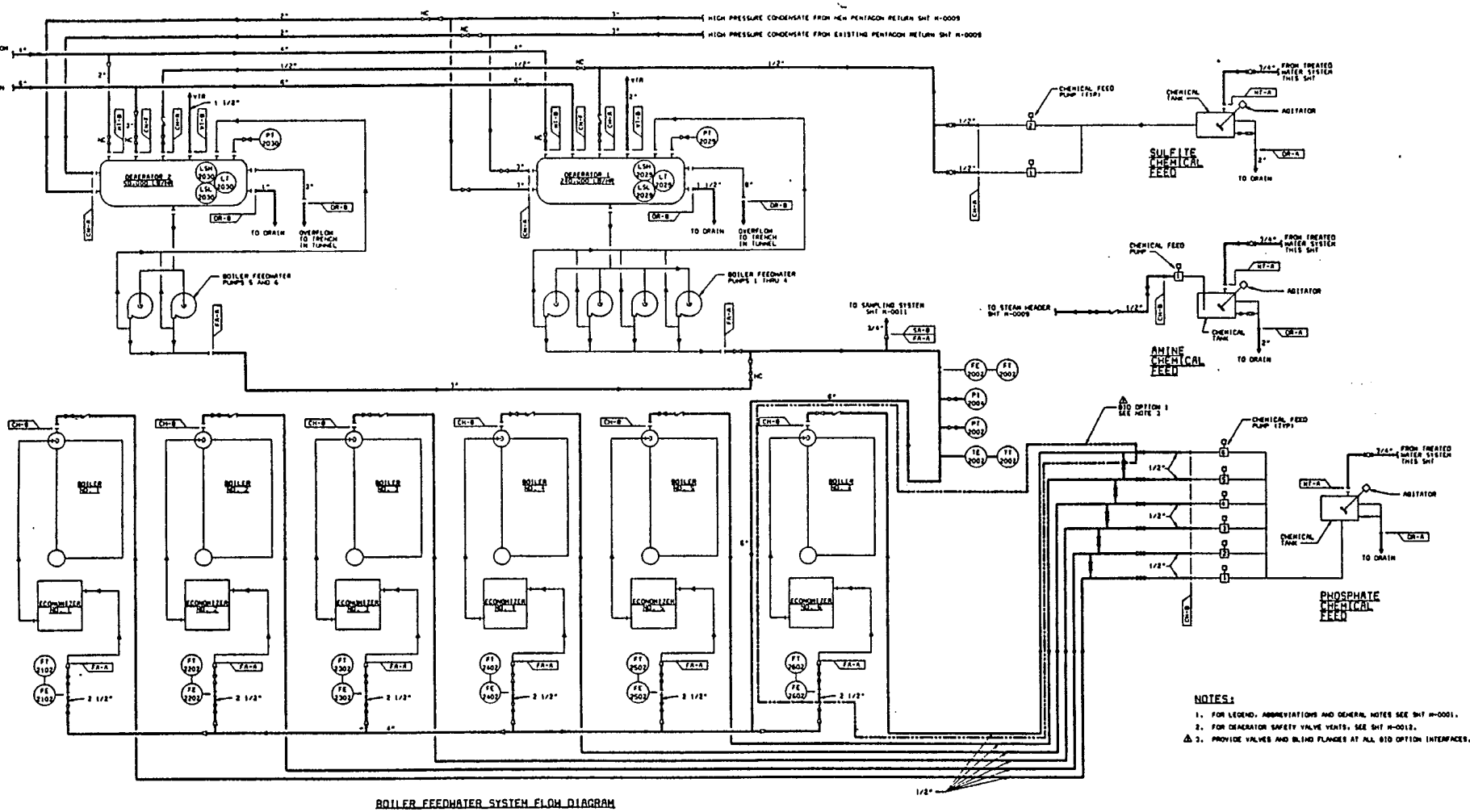


Figure B-16

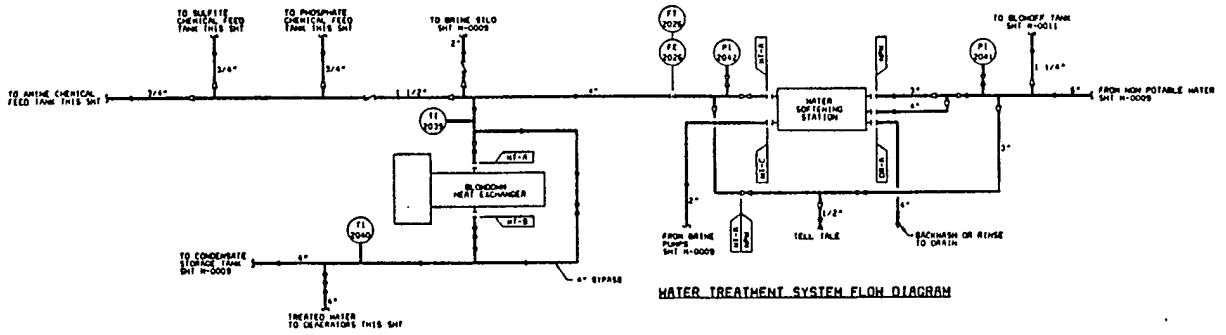
Sec Add #9, Item 119
(Addition of Note 10)
Sec Add #9 Item 95
(Addition of Note 9)



BOILER FEEDWATER SYSTEM FLOW DIAGRAM

NOTES:

1. FOR LEGEND, ABBREVIATIONS AND GENERAL NOTES SEE SHT M-0001.
2. FOR DEAERATOR SAFETY VALVE VENTS, SEE SHT M-0012.
3. PROVIDE VALVES AND BLIND FLANGES AT ALL BID OPTION INTERFACES.



WATER TREATMENT SYSTEM FLOW DIAGRAM

Figure B-17

REV	DATE	DESCRIPTION	BY
A	1SEP92	AMENDMENT NO. 18	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON - VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

BOILER FEEDWATER & WATER TREATMENT FLOW DIAGRAM

BLACK & VEATCH

DRAWING NUMBER F-821-90-46

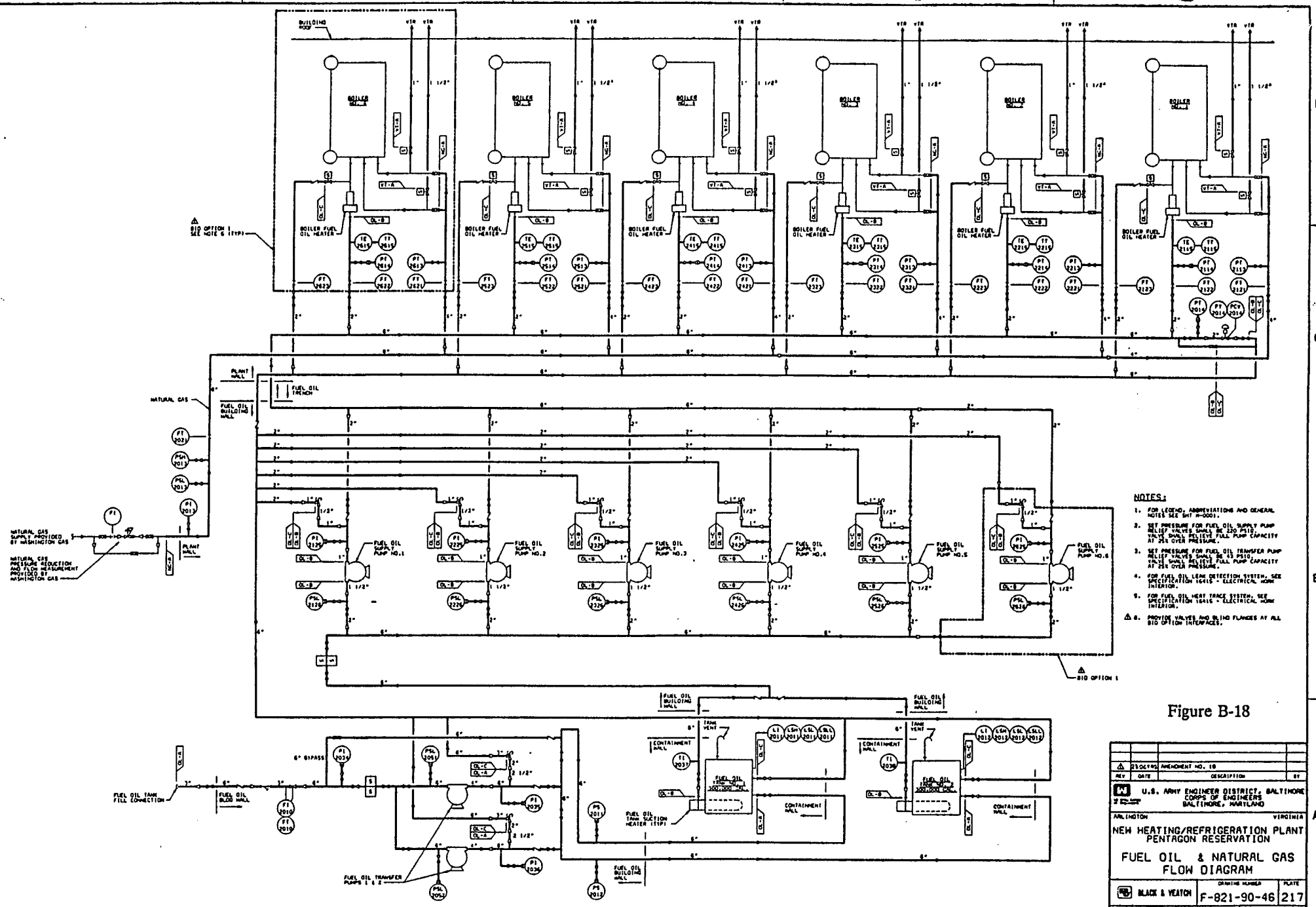
PLATE 215

SCALE: NONE

DATE: 21 FEB 92

SHEET M-0008

COD. 17182-900-CPT-ACF007



NOTES:

1. FOR LEGEND, ABBREVIATIONS AND GENERAL NOTES SEE SHT M-0001.
2. SET PRESSURE FOR FUEL OIL SUPPLY PUMP RELIEF VALVES SHALL BE 220 PSIG. VALVE SHALL RELIEVE FULL PUMP CAPACITY AT 25% OVER PRESSURE.
3. SET PRESSURE FOR FUEL OIL TRANSFER PUMP RELIEF VALVES SHALL BE 63 PSIG. VALVE SHALL RELIEVE FULL PUMP CAPACITY AT 25% OVER PRESSURE.
4. FOR FUEL OIL LEAK DETECTION SYSTEM, SEE SPECIFICATION 16415 - ELECTRICAL WORK INTERIOR.
5. FOR FUEL OIL HEAT TRACE SYSTEM, SEE SPECIFICATION 16415 - ELECTRICAL WORK INTERIOR.
6. PROVIDE VALVES AND BLIND FLANGES AT ALL BID OPTION INTERFACES.

Figure B-18

REV	DATE	DESCRIPTION	BY
1	25OCT92	AMENDMENT NO. 10	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

FUEL OIL & NATURAL GAS FLOW DIAGRAM

BLACK & VEATCH	DRAWING NUMBER	PLATE
	F-821-90-46	217
SCALE: NONE	DATE: 21 FEB 92	SHEET M-0010

CCD. 17102-900-CP1-ACP005

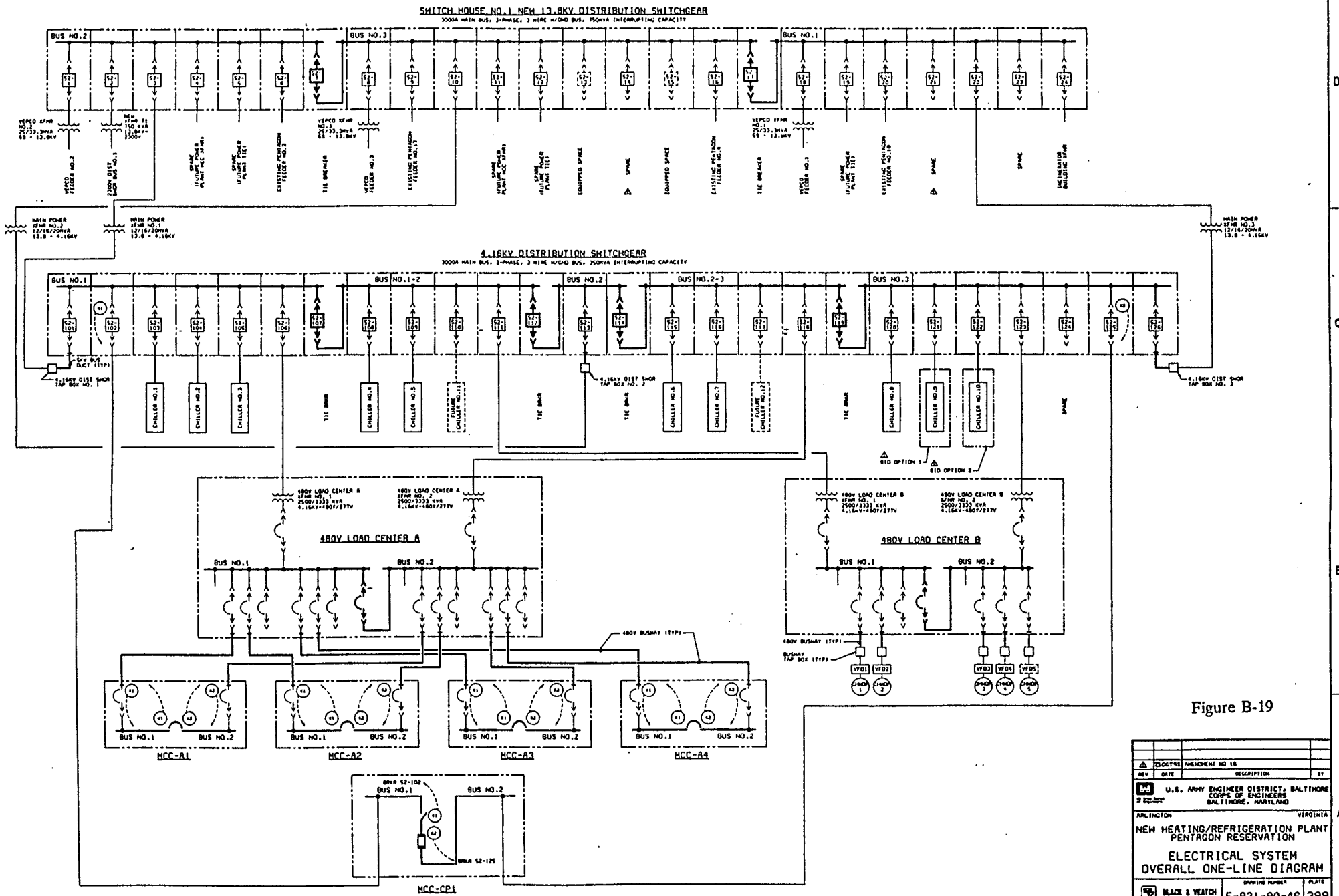


Figure B-19

REV	DATE	DESCRIPTION	BY
1	23 OCT 91	AMENDMENT NO 16	

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ARLINGTON VIRGINIA

NEW HEATING/REFRIGERATION PLANT
PENTAGON RESERVATION

ELECTRICAL SYSTEM
OVERALL ONE-LINE DIAGRAM

BLACK & VEATCH

DRAWING NUMBER: F-821-90-46

PLATE: 299

SCALE: NONE | DATE: 21 FEB 92 | SHEET E-3021

17162-900-001-ACF3021

APPENDIX C

New Heating and Refrigeration Plant Position Descriptions

New Heating and Refrigeration Plant Position Descriptions

This appendix provides position descriptions for the plant manager, operations and maintenance manager, general foreman, shift foreman, computer systems specialist, plant operator, repair mechanic, electrician, and electronic industrial controls mechanic. Position descriptions for the remainder of the personnel (pipefitter-welders and administrative staff) are essentially the same as the existing ones for the Pentagon Utilities Plant.

FEDERAL FACILITIES DIVISION
NEW HEATING AND REFRIGERATION PLANT
SUPERVISOR MECHANICAL ENGINEER
PLANT MANAGER

INTRODUCTION

The incumbent plans, directs, coordinates, controls, and evaluates all activities for the New Heating and Refrigeration Plant (NHRP) and is accountable for fulfilling obligations within budget and schedule. The plant is responsible for the production of steam and chilled water as well as the disposal of sewage. The plant generates high pressure steam and chilled water to supply the heating and cooling needs of the Pentagon, Navy Annex [Federal Office Building (FOB) 2], and Marine Corps Headquarters (Henderson Hall). The Pentagon Sewage Pump Station handles sewage from the Pentagon, FOB 2, and Arlington National Cemetery. The plant is in operation on a continuous, year-round basis and provides services to personnel and equipment essential to national defense.

The Plant Manager is responsible for the activities of approximately 40 employees engaged in technical, administrative, and various trades/crafts work.

The incumbent reports to the Director, Federal Facilities Division (FFD).

Until the NHRP, which is currently under construction, becomes operational, the Plant Manager will interface with the Pentagon Renovation and Planning Office through the FFD to participate in equipment and controls reviews from an operations and maintenance standpoint. The Plant Manager will assign NHRP personnel to training and start-up functions of new equipment and systems. The Plant Manager will initiate plans and programs to ensure NHRP personnel are trained and qualified to operate the plant at the time of turnover.

MAJOR DUTIES

Management

Manages the heating and refrigeration plant including operation, maintenance, repairs, and configuration control of the heating and cooling piping distribution systems to the buildings in a manner consistent with providing reliable heating and cooling to the Pentagon, FOB 2, and Henderson Hall.

Provides guidance and leadership to the NHRP organization and in the development of guidelines for the execution of all policies, procedures, and management activities on a continuing basis.

Cost Control

Is responsible for the budget and control of operation, maintenance, and repair costs for the plant and distribution systems.

Oversees the operation of the heating and refrigeration plant and associated distribution systems to minimize expenses.

Reviews, from a management cost savings viewpoint, technical requirements, workload plans, and other factors affecting the cost of scheduled performance of work activities.

Administers all contractual requirements and assigns tasks in accordance with the terms of contracts as they relate to NHRP activities.

Reports

Defines goals, maintains status and provides progress reports for the NHRP and submits such reports, as appropriate, to the Washington Headquarter Services (WHS)/FFD.

Evaluates systems and methods as encountered in the course of work and recommends ways to improve plant performance and methods.

Supervises the development of long-range plans and schedules.

Supervises the development of heating and refrigeration plant policy and procedure manuals, including work and record control procedures.

Personnel Administration

Maximizes utilization of manpower to minimize staffing levels. Has the authority to hire and to dismiss personnel to achieve efficiency and reliable, safe operation of the plant.

Manages labor relations of all NHRP personnel.

Is responsible for on-the-job training and for recommending training development of employees to increase their proficiency in satisfying current job requirements and to enhance their potential for advancement to more responsible positions.

General Administration

Administers the plant safety program, enforces safety rules and practices, and develops safe working practices.

Is qualified to perform first aid in the event of injuries to employees. Has a working knowledge of fire protection and the capabilities of equipment.

Ensures compliance with Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), and Department of Defense (DoD) regulations; appropriate American Society of Mechanical Engineers codes; National Board Inspection codes; and local and national fire and electrical codes.

Supports Equal Employment Opportunity program to ensure the hiring and development of qualified minorities, women, handicapped individuals, disabled veterans, and veterans of the Vietnam era.

Interim Duties

Reviews equipment and systems during construction of the NHRP to provide input on matters affecting operability and maintainability. Establishes training and qualification programs for the new equipment and systems to ensure personnel are qualified to operate the plant at the time of turnover. Assigns NHRP personnel to assist in initial start-up and operation in support of the turnover phase.

Other Duties

Performs other duties as assigned.

QUALIFICATIONS REQUIRED

Factor 1 — Knowledge Required by the Position

The incumbent is required to have a mastery of mechanical engineering principles, practices, and techniques, especially as related to large steam and refrigeration plant design, construction, and repair procedures. Such expertise is equivalent to that evidenced by possession of a Bachelor of Science in Engineering from an accredited college or university. This knowledge is needed to understand the theory and principles of the design of equipment and system functioning and to resolve complex mechanical and engineering problems related to functions involved with the repair, engineering, operation, and maintenance within the NHRP.

The incumbent must hold a District of Columbia Class 1 Steam Engineer License or an equivalent license (such as a marine engineering license) or have a minimum of three years experience as a supervisor of operations of a steam (100,000 lb/hr or greater capacity) and chiller (10,000 t/hr or greater capacity) plant. This knowledge factor provides evidence of practical experience in plant operations.

The incumbent must have knowledge of computerized distributed process control systems, including microprocessor-based controls and instruments, operator workstations, and automatic-to-manual control protocols. The NHRP is a fully automated plant utilizing state-of-the-art distributed process controls and requires an understanding of and ability to use a computer, software, and associated devices.

The incumbent must have knowledge of the essential elements of the Federal Personnel Manual (FPM) and DoD administrative instructions and policies to control, support, evaluate, discipline, etc., subordinates when necessary.

The incumbent must be able to communicate effectively both orally and in writing. This ability is necessary to present ideas, statements, interpretations, instructions, etc., to subordinates, superiors, agency representatives, contractors, and others.

Factor 2 — Supervisory Controls

The incumbent is responsible for overall personnel administration of the NHRP, including planning, assigning, and setting priorities for work to be accomplished by subordinates. Work assignments are made with knowledge of their difficulty and the ability of the subordinates. The incumbent reviews the productivity of employees, counseling and instructing them in both administrative and technical work matters.

The incumbent interviews candidates for transfer, promotion, or appointment to positions in the NHRP and recommends the appropriate personnel action.

The incumbent appraises subordinates as to need for development and training and keeps informed of classes, seminars, and engineering society meetings that subordinates may attend so that they may apply new knowledge derived therefrom to their daily work assignments.

The incumbent hears and resolves individual or small group complaints concerning NHRP. More serious, unresolved matters, such as large group or labor union complaints, are prepared for presentation to the Director, FFD.

The incumbent recommends necessary measures to resolve the more serious disciplinary cases and issues reprimands or suspensions in minor disciplinary cases.

Factor 3 — Guidelines

The DoD imposes general guidelines requiring that operations, maintenance, and repair be performed safely and efficiently and in accordance with Federal Property Management Regulations and with OSHA, EPA, and similar rules and regulations. Personnel administration is controlled by the FPM and Office of the Secretary of Defense administrative instructions. Due to the complex nature of the NHRP, considerable interpretation of guidelines is required of the incumbent.

Equipment and system operating guidelines include system descriptions, manufacturers' operating and maintenance instructions, power plant handbooks, established practices, and precedents from similar facilities.

The guidelines are frequently not wholly applicable to the work. The incumbent is required to use resourcefulness and judgement based on broad experience to develop solutions to the novel problems encountered in providing utility services to the various buildings.

Factor 4 — Complexity

The NHRP is a complex mechanical system integrated to produce the essential utility services, including steam for heating, chilled water for cooling, and compressed air for control. Numerous subsystems are employed, including fuel handling systems, high and low voltage electrical systems, condenser water system, and many more.

The Plant Manager operates under the general supervision of the Director, FFD. However, the Plant Manager has the authority for independent action in conducting the activities of the plant and in directing the work of subordinates. According to prescribed criteria, the Plant Manager makes decisions in matters other than those involving major policy. The Plant Manager ensures that plant procedures and guidelines follow overall policy and established General Services Administration and DoD procedures.

Factor 5 — Scope and Effect

Reliable utility services (steam, chilled water, and compressed air) and sewage removal are essential to create an environment where essential personnel and critical equipment of the DoD can perform assigned missions. The total failure of any system may jeopardize operations and prevent building occupants from performing their missions. The plant supports the Pentagon, Navy Annex, and other area buildings. The primary function of the Plant Manager is to ensure that plant services are reliably provided to the Pentagon and other buildings.

Factor 6 — Personal Contacts

Contacts are frequently required with the Director, FFD and various managers within WHS and FFD, with the NHRP Operations and Maintenance Manager and General Foreman, and with lower level employees who perform the day-to-day operations and repairs. In addition, the incumbent must contact managers in the using buildings and brief tenant agency officials. Contacts also are required with suppliers and equipment manufacturers.

Factor 7 — Purpose of Contacts

Contacts with the Director, FFD and tenant agency officials are made to determine needs, receive guidance, or conduct briefings about NHRP status or problems.

Contacts with subordinates are made to resolve complaints, issue instructions, conduct training, provide evaluations, etc.

Contacts with suppliers and equipment manufacturers are made to determine the scope of their preferred services and to evaluate their cost effectiveness.

Factor 8 — Physical Demands

Work involves some walking, standing, bending, stooping, crawling, and climbing of ladders to inspect equipment, repairs, or problems. Most work will be in an office environment.

Factor 9 — Work Environment

The incumbent works in an office environment the majority of the time, but may find it necessary to spend as much as 50 percent of the time touring and inspecting the steam generation plant, refrigeration plant, sewage pumping station, steam tunnels, manholes, etc., for several consecutive weeks. The operating areas are noisy, hot or cold, and dirty, and they contain moving equipment and pressurized piping systems, which can be hazardous if improperly operated. The plant contains asbestos and other hazardous chemicals that require special handling procedures and protection. Conditions require that appropriate safety gear such as hard hats, protective eye wear, and gloves be worn.

The incumbent must pass a physical examination annually with medical certification of ability to wear a negative pressure regulator.

FEDERAL FACILITIES DIVISION
NEW HEATING AND REFRIGERATION PLANT
SUPERVISOR MECHANICAL ENGINEER
OPERATIONS AND MAINTENANCE MANAGER

INTRODUCTION

The incumbent is responsible for the operation and maintenance of all equipment in the New Heating and Refrigeration Plant (NHRP). The plant is responsible for the production of steam and chilled water as well as the disposal of sewage. The plant generates high pressure steam and chilled water to supply the heating and cooling needs of the Pentagon, Navy Annex [Federal Office Building (FOB) 2], and Marine Corps Headquarters (Henderson Hall). The Pentagon Sewage Pump Station handles sewage from the Pentagon, FOB 2, and Arlington National Cemetery. The plant is in operation on a continuous, year-round basis and provides services to personnel and equipment essential to national defense.

The incumbent reports to the Plant Manager.

Until the NHRP, which is currently under construction, becomes operational, the Operations and Maintenance Manager will participate in equipment and system reviews, training, walkdowns, start-up, and testing to become fully qualified at the time of turnover.

MAJOR DUTIES

Management

Supervises personnel responsible for the operation and maintenance of equipment in the NHRP. Personnel supervised include the General Foreman, Shift Foremen, and Computer Systems Specialist.

Reviews plant and equipment operating conditions and load requirements to ensure that plant capability is maintained at the highest level within environmental constraints. Periodically tours the plant to check performance of shift personnel and to determine if equipment is operating satisfactorily and if safety standards are being met.

Prepares, or directs the preparation of, procedures for the proper operation of equipment, including start-up and shutdown, lay up, release for maintenance work, switching of related electrical equipment, and tagging of equipment taken out of service. Ensures that safety procedures are prepared and appropriate notices are posted where hazardous conditions may be present. Ensures that procedures are implemented and that personnel are trained and qualified to maintain the safe, efficient, economical, and dependable operation of the plant.

Reviews digital computer operations and has complete knowledge of the functioning of computerized distributed control systems, including electronic signal processors, analog-to-digital converters, fiber optic transmission links, data networks, programmable logic controllers, distributed process controllers, and microprocessor-based monitoring instrumentation.

Specifies the practices to be followed in implementing maintenance work orders by shift personnel, including postrepair inspection and testing.

Ensures that records of all operations and pertinent shift activities are properly logged and retained.

Identifies, develops, and implements recommendations for improvements in operations and safety practices.

Determines if fuel deliveries and reserves are adequate and will meet consumption requirements and determines if other supplies, materials, and equipment are available to meet operational requirements.

Maintains the current status of mechanical and electrical equipment in and out of service. Determines causes of unusual or improper operation and operating conditions and of equipment failure, and takes necessary action to prevent recurrence of improper operation or equipment failure.

Reports

Prepares weekly, monthly, and yearly reports of operations. Those reports summarize plant and personnel performance, identify areas where improvements are needed, and recommend improvements. Prepares reports as directed by the Plant Manager.

Personnel Administration

Prepares shift assignments. Establishes duties of personnel for all anticipated evolutions and emergency situations. Periodically conducts drills for emergency situations and arranges for training where necessary.

Assists in maintaining effective employee relations in the plant. Reviews time and attendance records. Evaluates employee performance, takes appropriate disciplinary action, and works with union stewards to resolve problems.

Is responsible for the training and development of employees to increase their proficiency in satisfying current job requirements and enhance potential to advance to more responsible positions.

General Administration

Supervises and administers the plant safety program, enforces safety rules and practices, and develops safe working practices.

Is qualified to perform first aid in the event of injuries to employees. Has a working knowledge of fire protection and the capabilities of equipment.

Supports Equal Employment Opportunity program to ensure the hiring and development of qualified minorities, women, handicapped individuals, disabled veterans, and veterans of the Vietnam era.

Supports management programs such as charity and bond campaigns.

Interim Duties

Supervises operating personnel and participates in the start-up and testing on equipment and systems of the NHRP during the time of construction.

Other Duties

Performs other duties as assigned.

QUALIFICATIONS REQUIRED

Factor 1 — Knowledge Required by the Position

The incumbent must have knowledge of professional engineering principles, practices, and techniques, especially as related to large steam and refrigeration plant design, construction, and repair procedures. Such expertise is equivalent to that evidenced by possession of a Bachelor of Science in Engineering from an accredited college or university. This knowledge is needed to understand the theory and principles of the design of equipment and system functioning and to transcribe this understanding into procedures and practices.

The incumbent must hold a District of Columbia Class 1 Steam Engineer License or an equivalent license (such as a marine engineering license) or have a minimum of three years experience as a supervisor of operations of a steam (100,000 lb/hr or greater capacity) and chiller (10,000 t/hr or greater capacity) plant. This knowledge factor provides evidence of practical experience in plant operations.

The incumbent must have knowledge of computerized distributed process control systems, including microprocessor-based controls and instruments, operator workstations, and automatic-to-manual control protocols. The NHRP is a fully automated plant utilizing state-of-the-art distributed process controls and requires an understanding of and ability to use a computer, software, and associated devices.

Knowledge of the essential elements of the Federal Personal Manual (FPM) and Department of Defense (DoD) administrative instructions and policies to control, support, evaluate, discipline, etc., subordinates when necessary.

Ability to communicate effectively both orally and in writing. This ability is necessary to present ideas, statements, interpretations, instructions, etc., to subordinates, superiors, agency representatives, contractors, and others.

Factor 2 — Supervisory Controls

The incumbent is responsible for supervision of operations and maintenance personnel, including planning, assigning, and setting priorities for work to be accomplished. The incumbent ensures that procedures are developed for anticipated evolutions and emergency situations; monitors plant operations and maintenance and personnel performance to ensure that procedures are properly implemented; and reviews the work and productivity of personnel, giving counsel and instruction in both administrative and technical work matters.

The incumbent evaluates the adequacy of staffing and determines if augmentation or replacements are necessary. The incumbent interviews candidates for assignment to shift duties and selects personnel for transfer, promotion, or appointment to positions in operation and maintenance of the NHRP.

The incumbent evaluates personnel as to need for development and training and schedules classes, training and meetings to improve or maintain proficiency of the operating staff.

The incumbent participates in the review of complaints concerning shift operation; participates in the resolution of complaints; and recommends reprimands or suspensions, as appropriate.

Factor 3 — Guidelines

The DoD imposes general guidelines requiring that operations, maintenance, and repair be performed safely and efficiently and in accordance with Federal Property Management Regulations and with Occupational Safety and Health Administration, Environmental Protection Agency, and similar rules and regulations. Personnel administration is controlled by FPM and Office of the Secretary of Defense administrative instructions. Specific guidelines for personnel administration of the NHRP are to be implemented by the Operations and Maintenance Manager.

Equipment and system operating guidelines include system descriptions, manufacturers' operating and maintenance instructions, power plant handbooks, established practices, and precedents from similar facilities. The Operations and Maintenance Manager utilizes all appropriate references in formulating operating procedures for the specific equipment and systems in NHRP.

The guidelines are frequently not wholly applicable to the work. The incumbent is required to use resourcefulness and judgment based on broad experience to develop solutions to the novel problems encountered in providing utility services to the various buildings.

Factor 4 — Complexity

The NHRP is a complex mechanical system integrated to produce the essential utility services, including steam for heating, chilled water for cooling, and compressed air for control. Numerous subsystems are employed, including fuel handling systems, high and low voltage electrical systems, condenser water system, and many more. It is the responsibility of the Operations and Maintenance Manager to ensure that appropriate procedures are in place and that operating and maintenance personnel are properly trained to ensure the safe and efficient operation of the NHRP. This responsibility requires a combination of technical leadership and motivational skills in dealing with mechanical, electrical, and electronic equipment and with people of various levels of knowledge and experience. Therefore, procedures must be tailored to the needs of the equipment as well as to the skill levels of assigned personnel, and training programs formulated to assure essential operations are specified for safe operation, while raising the level of knowledge of personnel.

The Operations and Maintenance Manager is under the direction of the Plant Manager. However, the Operations and Maintenance Manager has the authority for independent action in directing the work of subordinates to provide safe and efficient operation according to prescribed instructions and guidelines.

Factor 5 — Scope and Effect

Reliable utility services (steam, chilled water, and compressed air) and sewage removal create an environment where the essential personnel and critical equipment of the DoD can perform assigned missions. Failure of utility services may jeopardize operations and prevent building occupants from performing assigned missions. The plant supports the Pentagon, Navy Annex, and other area buildings.

The Operations and Maintenance Manager's primary function is to ensure that personnel are properly instructed and trained for the safe and efficient operation and maintenance of NHRP equipment to maintain utility service to the Pentagon and other buildings.

Factor 6 — Personal Contacts

Contacts are required with the Plant Manager, General Foreman, Shift Foremen, and Computer Systems Specialist, as well as with lower level employees who perform the day-to-day operations and repairs. In addition, the incumbent meets with contractors, equipment manufacturers, and others involved with providing supplies or services to the NHRP.

Factor 7 — Purpose of Contacts

Contact with the Plant Manager is made to receive direction and guidance and to provide briefings about equipment and systems status or problems. Information and recommendations are given regarding personnel performance and problems.

Contacts with peers and subordinates are made to resolve complaints, issue instructions, conduct training, provide evaluations, etc.

Contacts with contractors and equipment manufacturers are made to provide direction, ensure plant and personnel safety, and understand the work they are assigned to perform.

Factor 8 — Physical Demands

Work is in an office as well as in power plant equipment spaces and involves significant walking, standing, bending, stooping, crawling, and climbing of ladders to inspect equipment, repairs, or problems.

Factor 9 — Work Environment

The work environment includes offices, control room, switchgear rooms, and operating equipment areas, including the steam generation plant, refrigeration plant, sewage pumping station, steam tunnels, manholes, etc. The operating areas are noisy, hot or cold, and dirty, and they contain moving parts, high voltage equipment, and pressurized piping systems, all of which can be hazardous if improperly operated. The plant contains hazardous chemicals that require special handling procedures and protection. Conditions require that appropriate safety gear such as hard hats, protective eye wear, and gloves be worn.

The incumbent must pass a physical examination annually with medical certification of ability to wear a negative pressure regulator.

FEDERAL FACILITIES DIVISION
NEW HEATING AND REFRIGERATION PLANT
UTILITY SYSTEMS REPAIRER OPERATOR
GENERAL FOREMAN

INTRODUCTION

The incumbent is responsible for the maintenance of all equipment in the New Heating and Refrigeration Plant (NHRP). The plant is responsible for the production of steam and chilled water as well as the disposal of sewage. The plant generates high pressure steam and chilled water to supply the heating and cooling needs of the Pentagon, Navy Annex [Federal Office Building (FOB) 2], and Marine Corps Headquarters (Henderson Hall). The Pentagon Sewage Pump Station handles sewage from the Pentagon, FOB 2, and Arlington National Cemetery. The plant is in operation on a continuous, year-round basis and provides services to personnel and equipment essential to national defense.

The incumbent reports to the Operations and Maintenance Manager.

Until the NHRP, which is currently under construction, becomes operational, the General Foreman will participate in equipment and system reviews, training, walkdowns, start-up, and testing to become fully qualified at the time of turnover.

MAJOR DUTIES

Supervises personnel responsible for the maintenance of equipment in the NHRP. Personnel supervised include the Repair Mechanics, Electricians, Electronic Industrial Controls Mechanics, and Pipefitter-Welders.

Reviews equipment operating conditions and maintenance status to ensure that equipment availability is sufficient to ensure that plant services are met. Periodically makes tours of plant to check performance of shift and maintenance personnel and to determine if equipment is operating satisfactorily and if safety standards are being met.

Prepares, or directs the preparation of, procedures for the proper maintenance of equipment, including steps for proper shutdown and isolation, layup, release for maintenance work, switching of related electrical equipment, and tagging of equipment taken out of service. Ensures that safety precautions are specified where hazardous conditions may be present. Ensures that procedures

are implemented and that personnel are trained and qualified to perform maintenance safely, efficiently, and economically.

Reviews digital computer operations and understands the functioning of computerized distributed control systems, including electronic signal processors, analog-to-digital converters, fiber optic transmission links, data networks, programmable logic controllers, distributed process controllers, and microprocessor-based monitoring instrumentation.

Specifies the practices to be followed in implementing maintenance work orders including postrepair inspection and testing.

Ensures that records of all maintenance activities are properly logged and retained.

Identifies, develops, and implements recommendations for improvements in maintenance and safety practices.

Determines if supplies, parts, materials, and equipment are available to meet maintenance requirements.

Tracks the status of mechanical and electrical equipment in and out of service. Determines causes of unusual or repeated failures and takes necessary action to prevent recurrence.

SKILL AND KNOWLEDGE

The incumbent has knowledge of principles and is skilled in the practices and techniques for the maintenance and operation of large steam and refrigeration plant electrical and mechanical systems and equipment. Evidence of a minimum of five years experience as a lead repair mechanic or lead electrician in a steam generation and chiller plant is required. This knowledge and experience is needed to understand the functioning of equipment and systems and to transcribe this understanding into procedures and practices.

The incumbent olds a District of Columbia Class 1 Steam Engineer License or an equivalent license (such as a marine engineering license), or has a minimum of three years experience as an operator in a large steam (100,000 lb/hr or greater capacity) and chiller (10,000 t/hr or greater capacity) plant. This knowledge provides evidence of practical experience in plant operations.

The incumbent has knowledge of computerized distributed process control systems, including microprocessor-based controls and instruments, operator workstations, and automatic-to-manual control protocols. The NHRP is a fully automated plant utilizing state-of-the-art distributed process controls and requires an understanding of and ability to use a computer, software, and associated devices.

The incumbent has knowledge of the essential elements of the Federal Personnel Manual (FPM) and Department of Defense (DoD) administrative instructions and policies to control, support, evaluate, discipline, etc., subordinates when necessary.

The incumbent can communicate effectively both orally and in writing. This ability is necessary to present ideas, statements, interpretations, instructions, etc., to subordinates, superiors, agency representatives, contractors, and others.

RESPONSIBILITIES

Is responsible for supervision of maintenance personnel. Plans, assigns, and sets priorities for work to be accomplished. Establishes duties of personnel. Ensures that procedures are developed for anticipated maintenance activities and emergency situations. Monitors equipment maintenance and personnel performance to ensure that procedures are properly implemented.

Evaluates the adequacy of staffing and determines if augmentation or replacements are necessary. Interviews candidates for assignment to maintenance duties. Prepares input for the selection of personnel for transfer, promotion, or appointment to positions in operation and maintenance of the NHRP.

Is responsible for the training and development of maintenance personnel to increase their proficiency in satisfying current job requirements and to enhance potential to advance to more responsible positions. Evaluates personnel as to the need for development and training. Schedules classes, training, and meetings to improve or maintain proficiency of the maintenance staff.

Reviews time and attendance records.

Reviews the work and productivity of personnel, giving counsel and instruction in both administrative and technical work matters. Evaluates employee performance. Works with union stewards to resolve problems. Participates in the review of complaints concerning maintenance personnel. Participates in the resolution of complaints. Recommends reprimands or suspensions, as appropriate.

Prepares weekly, monthly, and yearly reports of maintenance activities, summarizing plant and personnel performance, identifying areas where improvements are needed, and recommending improvements. Prepares reports as directed by the Operations and Maintenance Manager.

Assists in the administration of the plant safety program, enforces safety rules and practices, and develops safe working practices.

Is qualified to perform first aid in the event of injuries to employees and has a working knowledge of fire protection and the capabilities of equipment.

Supports Equal Employment Opportunity program to ensure the hiring and development of qualified minorities, women, handicapped individuals, disabled veterans, and veterans of the Vietnam era.

Supports management programs such as charity and bond campaigns.

Provides supervision of maintenance personnel and participates in the start-up and testing on equipment and systems of the NHRP during the time of construction.

Performs other duties as assigned.

PHYSICAL EFFORT

Work involves significant walking, standing, bending, stooping, crawling, climbing of ladders, use of tools, and lifting of heavy items to inspect equipment, perform repairs, or correct problems.

WORKING CONDITIONS

The incumbent works in operating equipment areas inspecting the steam generation plant, refrigeration plant, sewage pumping station, steam tunnels, manholes, etc. The operating areas are noisy, hot or cold, and dirty, and they contain moving equipment and pressurized piping systems, which can be hazardous if improperly operated. The plant contains hazardous chemicals that require special handling procedures and protection. Conditions require that appropriate safety gear such as hard hats, protective eye wear, and gloves be worn.

The incumbent must pass a physical examination annually with medical certification of ability to wear a negative pressure regulator.

FEDERAL FACILITIES DIVISION
NEW HEATING AND REFRIGERATION PLANT
UTILITY SYSTEMS REPAIRER OPERATOR
SHIFT FOREMAN

INTRODUCTION

The incumbent is assigned to rotating shift work and supervises the operation and preventive maintenance tasks related to boilers, chillers and auxiliaries as directed by the Operations and Maintenance Manager. The position is located in the New Heating and Refrigeration Plant (NHRP). The plant is responsible for the production of steam and chilled water as well as the disposal of sewage. The plant generates high pressure steam and chilled water to supply the heating and cooling needs of the Pentagon, Navy Annex [Federal Office Building (FOB) 2], and Marine Corps Headquarters (Henderson Hall). The Pentagon Sewage Pump Station handles sewage from the Pentagon, FOB 2, and Arlington National Cemetery. The plant is in operation on a continuous, year-round basis and provides services to personnel and equipment essential to national defense.

The incumbent reports to the General Foreman.

Until the NHRP, which is currently under construction, becomes operational, the Shift Foreman will participate in equipment and system reviews, training, walkdowns, start-up, and testing to become fully qualified at the time of turnover.

MAJOR DUTIES

Supervises start-up and shutdown of equipment, release of equipment for maintenance work, switching of any related electrical equipment, and tagging of equipment taken out of service.

Observes, controls, and maintains plant operating conditions and load requirements and maintains plant capability at the highest level within environmental constraints.

Operates and supervises personnel in the operation of the computerized distributed control systems, including electronic signal processors, analog-to-digital converters, fiber optic transmission links, data networks, programmable logic controllers, distributed process controllers, and microprocessor-based monitoring instrumentation; the operation of local computerized and analog control

systems; and the steps to be taken to switch between computer control and manual operation.

Makes inspection tours during the assigned shift to check the operating conditions of plant equipment, gauges, charts, and records, and to make certain that all equipment is operating satisfactorily and is loaded efficiently and safely. Makes changes necessary for good operation, reporting abnormal conditions and unusual situations to the Operations and Maintenance Manager.

Plans shift work assignments, instructs and trains employees in job duties, checks progress and reviews results, and provides directions and instructions to employees to maintain maximum efficiency and safety in operation of the unit.

Assists in maintaining effective employee relations in the plant. Checks that time and attendance records are properly maintained, evaluates employee performance, takes appropriate disciplinary action, and works with union stewards to resolve problems.

Investigates and inspects mechanical and electrical equipment in and out of service to check the status of equipment and ensure coordination of plant activities. Determines causes of unusual or improper operation and operating conditions, determines causes of equipment failure, and takes necessary action to prevent recurrence of improper operation or equipment failure.

Makes recommendations for improvements in operations and safety practices.

SKILL AND KNOWLEDGE

The incumbent has knowledge of principles and is skilled in practices of the operation of large-scale steam and refrigeration plants. This is necessary to understand equipment and system functioning and the basis for requirements in operation and maintenance procedures.

The incumbent holds a District of Columbia Class 1 Steam Engineer License or an equivalent license (such as a marine engineering license), or has a minimum of three years experience as a foreman or lead person in charge of shift operations of a steam (100,000 lb/hr or greater capacity) and chiller (10,000 t/hr or greater capacity) plant. This knowledge provides evidence of practical experience in plant operations.

The incumbent has knowledge of equipment in the systems and is skilled in the kind and quality of materials and equipment to be used in performing various checks, tests, adjustments, and troubleshooting tasks at the system level to determine the operational performance of the equipment and the need for adjustment or repair.

The incumbent has knowledge of computerized distributed process control systems, including microprocessor-based controls and instruments, operator workstations, and automatic-to-manual control protocols, and of the functioning of equipment when operating the boiler and chiller control workstations as well as the managers' workstations. The incumbent recognizes malfunctions of computer controls and knows the proper steps to take to initiate manual control. The NHRP is a fully automated plant utilizing state-of-the-art distributed process controls and requires an understanding of and ability to use a computer, software, and associated devices.

The incumbent has knowledge of controls of all plant systems. Using either computer or local or manual controls, the incumbent is able to put each system into operation, safely shut each system down, and isolate major components for maintenance and repairs, and understands and can perform all system operations. This knowledge is necessary because of the reduced manning level for shift operations, and considering the vulnerability of the fully automated features of the plant.

The incumbent has knowledge of the essential elements of the Federal Personnel Manual (FPM) and Department of Defense (DoD) administrative instructions and policies to control, support, evaluate, discipline, etc., subordinates when necessary.

The incumbent is qualified to perform first aid in the event of injuries to employees and has a working knowledge of fire protection and the capabilities of equipment.

RESPONSIBILITIES

Carries out duties assigned by the Operations and Maintenance Manager.

Is responsible for supervising assigned shift. Plans, assigns, and sets priorities for work to be accomplished by the operations and maintenance subordinates. Assigns work with knowledge of the difficulty of the work and the ability of the subordinate. Checks all repairs of major equipment (boilers, chillers, pumps, air compressors, heat exchangers etc., before start-up of equipment). Reviews the work and productivity of shift employees, giving counsel and instruction in both administrative and technical work matters.

Ensures that operating procedures are properly implemented and that work practices follow established procedures. Applies judgment, based on experience, to handle abnormal situation. Recognizes emergency situations and initiates immediate corrective actions to prevent or minimize unsafe consequences.

Interviews candidates for assignment to shift duties. Recommends transfer, promotion, or appointment to positions in the NHRP, and recommends the appropriate personnel action.

Assists in the training and development of employees to increase proficiency in satisfying current job requirements and enhance potential to advance to more responsible positions. Appraises the Operations and Maintenance Manager as to need for development and training of shift personnel. Keeps informed of classes and meetings that subordinates may attend so that they may apply new knowledge derived from daily work assignments.

Participates in the review of individual or small group complaints concerning shift operation. More serious, unresolved matters, such as large group or labor union complaints, may require input but are the responsibility of NHRP management.

Provides recommendations for the resolution of the more serious disciplinary cases. In the instance of minor disciplinary cases, recommends reprimands or suspensions.

Enforces safety rules and practices, and develops safe working practices.

In the absence of the Operations and Maintenance Manager and the Plant Manager, assumes full responsibility for operation of the facility.

In the absence of the General Foreman, issues maintenance work orders and inspects/evaluates corrective measures. Coordinates plant operational and maintenance/repair activities occurring on the shift.

Prepares records of all operations and changes during the shift, and prepares or checks all daily operating reports.

Inspects minor construction work and the maintenance and repair of all electrical, mechanical, and other auxiliary and associated equipment.

Observes and enforces the efficient and economical use, care, and handling of operating tools and supplies; observes fuel inventories and informs the Operations and Maintenance Manager if supplies are adequate and will meet consumption requirements; and determines if other supplies, materials, and equipment are available to meet operational requirements.

Prepares reports as directed by the Operations and Maintenance Manager.

Supervises operating personnel and participates in the start-up and testing of equipment and systems of the NHRP during construction.

PHYSICAL EFFORT

Work involves significant walking, standing, bending, stooping, crawling, climbing of ladders, use of tools, and lifting of heavy items to inspect equipment, perform repairs, or correct problems.

WORKING CONDITIONS

The incumbent works in operating equipment areas inspecting the steam generation plant, refrigeration plant, sewage pumping station, steam tunnels, manholes, etc. The operating areas are noisy, hot or cold, and dirty, and they contain moving equipment and pressurized piping systems, which can be hazardous if improperly operated. The plant contains hazardous chemicals that require special handling procedures and protection. Conditions require that appropriate safety gear such as hard hats, protective eye wear, and gloves be worn.

The incumbent must pass a physical examination annually with medical certification of ability to wear a negative pressure regulator.

FEDERAL FACILITIES DIVISION
PENTAGON NEW HEATING AND REFRIGERATION PLANT
COMPUTER SYSTEMS SPECIALIST

INTRODUCTION

The incumbent is responsible for the maintenance of computer software and hardware for systems and plant controls, and for data acquisition and logging for the Pentagon New Heating and Refrigeration Plant (NHRP). The plant is responsible for the production of steam and chilled water as well as the disposal of sewage. The plant generates high pressure steam and chilled water to supply the heating and cooling needs of the Pentagon, FOB-2 and Henderson Hall Marine Barracks. The Pentagon Sewage Pump Station handles sewage from the Pentagon, FOB-2 Complex and the Arlington National Cemetery. The plant is in operation on a continuous, year-round basis and provides services to personnel and equipment essential to national defense.

The incumbent reports to the Operations and Maintenance Manager.

Until the NHRP, which is currently under construction, becomes operational, the Computer Systems Specialist will participate in equipment and system reviews, training, walkdowns, startup and testing to become fully qualified at the time of turnover.

MAJOR DUTIES

Responsibilities

Responsible for the maintenance and modification of the computer programs used for central control of plant equipment and also the programs used for local control of equipment. Principal equipment controlled and/or monitored by the computer programs includes boilers, chillers, pumps, fans, compressors and valves.

Responsible for performing system diagnostic tests to identify and isolate sources of malfunctions, either of a program logic type, computer hardware type or instrument type. Hardware and software includes the various instruments and devices used for the control of boiler and chiller systems including smart combustion gas analyzers, combustion air controls, feedwater system controls, electronic registers associated with the flow monitors, digital process loop controllers, programmable conductivity transmitters and programmable bargraph

displays, refrigeration system controls, plant heating, ventilation and air conditioning controls, data loggers, numerous electrical, pneumatic, and hydraulic control systems and subsystems, telephone systems and plant security systems. Devices include microprocessor-based flame safety and boiler signal transmitters, analog-to-digital (pneumatic/hydraulic/ electrical to electronic) transducers, valve positioners, ring balance meters, differential pressure transmitters, pneumatic feed back controllers, oxygen trim controllers, electronic and pneumatic temperature, pressure and flow measuring and transmitting devices, and electronic/pneumatic graph recorders.

Technical Direction

Provides instructions for the inspection, calibration, maintenance and tuning of computer-based instruments and controls. Has knowledge of the diagnoses, tests and repairs necessary to restore malfunctioning instruments and controls. Assists in the investigation of major equipment failures where computer programs, instrumentation or controls may be involved.

Prepares specifications for new computer hardware, software, and electronic devices and instruments.

Prepares operating procedures for using the central distributed computer for plant control. Provides training for operations personnel.

Prepares maintenance procedures for instruments and electronic devices. Provides training for maintenance personnel.

Technical Duties

Analyzes various computer control programs and plant systems and specifies adjustments and modifications to upgrade these systems so as to improve the overall reliability and efficiency of the systems as a whole. Checks out newly purchased computer hardware and software to ensure it functions properly before releasing it for use. Specifies startup tests and checks for newly installed instruments and controls. Modifies working drawings to reflect changes made.

General Administration

Qualified to perform first aid in the event of injuries to employees. Has a working knowledge of fire protection and the capabilities of equipment.

Follows the plant safety rules and practices. Incorporates safe working practices into operating and maintenance procedures.

Supports management programs such as charity and bond campaigns.

Interim Duties

Provides assistance to operating personnel and participates in the startup and testing on equipment and systems of the NHRP during the time of construction.

Other Duties

Performs other duties as assigned.

FACTOR STATEMENTS

Factor 1 – Knowledge Required by the Position

Knowledge of digital computer theory and design. Knowledge of the fundamentals of computer programming. Such knowledge is equivalent to that evidenced by possession of a Bachelor's Degree in Computer Science from an accredited College or University. This knowledge is needed to understand the theory and design of computer control systems and to apply this understanding to the operation and diagnosis of industrial process controls and for the preparation of procedures for use by operating and maintenance personnel.

Knowledge of the theory related to electronic, electrical and pneumatic instrumentation and controls and digital equipment for industrial process applications. This knowledge is necessary for diagnosing problems and for the preparation of procedures for analyzing, testing, troubleshooting, repairing and calibrating such devices and systems.

Knowledge of computer control systems for industrial applications, including (1) configuration and operation of computer software and programming in multi-tasking operating systems such as QNX and disk operating systems; (2) network hardware and software and communication protocols (familiarity with Bristol Standard Asynchronous Protocol (BSAP) is desirable); (3) fiber optic data highways (familiarity with Arcnet is desirable); (4) communication hardware, including serial and parallel communication RS-232 and RS-485 connectors, and electronic and fiber optic modems; (5) Programmable Logic Controllers (PLCs) and Distributed Process Controllers (DPCs), and knowledge of ladder logic and how to reprogram ladder logic (familiarity with Bristol Babcock ACCOL programming language is desirable); (6) 486 PC workstations and uninterruptible power supplies; and (7) microprocessor-based monitoring instrumentation including intelligent digital pressure, temperature, and level transmitters, electronic registers associated with flow monitors, digital process loop controllers, smart combustion gas analyzers, programmable conductivity transmitters and

programmable bargraph displays. Knowledge of these systems and instruments is necessary because their proper functioning is essential for the safe and efficient operation of the NHRP.

Working knowledge of central heating boiler systems and central station refrigeration systems and their operation. This knowledge is necessary to understand the process application of controls and instruments in performing training and diagnostic testing and in the preparation of procedures.

Ability to communicate effectively both orally and in writing. This ability is necessary to present ideas, statements, interpretations, instructions, etc., to fellow workers, superiors, agency representatives, contractors, and others.

Factor 2 – Supervisory Controls

Carries out duties assigned by the Operations and Maintenance Manager. Responds to requests made by shift personnel for technical assistance in the operation or repair of computer-based systems and especially the Distributed Control System. Responsible for establishing the schedule, extent and frequency of diagnostic testing of computer systems and for directing the implementation of the testing program. Performs checks to ensure the control systems are functioning properly and to specify steps to follow for off-design conditions.

Carries out normal and routine duties with minimal supervision. Independently takes corrective measures in response to abnormal occurrences or malfunctions and reports such activities to the Shift Foreman and Operations and Maintenance Manager.

Provides assistance to shift personnel, maintenance technicians and equipment service representatives in the proper operation and/or maintenance of computer-based systems and associated instruments and controls.

Factor 3 – Guidelines

Guidelines include equipment technical instructions, system descriptions, handbooks, and established practices and precedents from similar facilities. In the absence of detailed guidelines, the Computer Systems Specialist applies first principle knowledge and past experience. Adaptations may be necessary in situations where abnormal conditions develop or in emergencies.

The guides are frequently not wholly applicable to the work. The incumbent is required to use resourcefulness and judgement based on broad experience to develop solutions to the novel problems encountered in ensuring proper functioning of the control systems.

Factor 4 – Complexity

Control of the NHRP is by a complex digital system employing a variety of different mechanical, electrical and electronic equipment which serves to produce the essential utility services including steam for heating, chilled water for cooling, and compressed air for control. Numerous subsystems are employed including fuel handling systems, high and low voltage electrical systems, condenser water system and many more.

The Computer Systems Specialist routinely performs highly skilled tasks requiring familiarity with computer hardware and programs, and analog and digital devices for the analysis of systems functioning. Identification of corrective actions requires a broad base of knowledge and experience in understanding the interfaces between electro-mechanical systems and digital controls. The Computer Systems Specialist will be called upon to diagnose malfunctions and to restore controls requiring novel, unplanned approaches and skills derived from experience with a variety of problems. The Computer Systems Specialist is under the direction of the Operations and Maintenance Manager but has the responsibility to take independent action in performing tasks to ensure the safety of plant personnel and proper functioning of equipment control systems.

Factor 5 – Scope and Effect

Reliable utility services (steam, chilled water, compressed air and sewage removal) create an environment where the essential personnel and critical equipment of the DoD can perform assigned missions. Failure of utility services may jeopardize operations and prevent building occupants from performing assigned missions. The plant supports the Pentagon, Navy Annex, and other area buildings.

The Computer System Specialist's primary function is to ensure that the plant computer-based control systems operate properly for the safe and efficient operation of NHRP systems to maintain utility service to the Pentagon and other buildings.

Factor 6 – Personal Contacts

Contacts are required with the Shift Foremen, USRO General Foremen, Plant Manager, Shift Personnel and other employees who perform the day-to-day operations and repairs. Contacts are required with contractors and equipment manufacturers.

Factor 7 – Purpose of Contacts

Contacts with Plant Management and the Shift Foremen are made to receive situation and status reports and instructions, and to provide direction for the resolution of problems, or to provide training, etc.

Contacts with other NHRP personnel are to provide direction and to obtain information concerning the operation and maintenance of equipment, instruments and systems.

Contacts with contractors and equipment manufacturers are to provide direction, obtain information, receive training, ensure plant procedures are followed, and when assigned in a quality control role, ensure work meets contract document requirements.

Factor 7 – Physical Demands

Work is at the control stations at computer terminals and also in operating areas, which involves significant walking, standing, bending, stooping, crawling, and climbing of ladders to review equipment, repairs, and problems.

Factor 9 – Work Environment

The work environment includes offices, control room, switchgear rooms and operating equipment areas including the steam generation plant, refrigeration plant, sewage pumping station, steam tunnels, manholes, etc. The operating areas are noisy, hot or cold, dusty and dirty and contain moving parts, high voltage equipment and pressurized piping systems, all of which can be hazardous if improperly operated. The plant contains hazardous chemicals which require special handling procedures and protection. Conditions require that appropriate safety gear such as hard hats, protective eye wear and gloves be worn.

Incumbent must pass physical examination annually with medical certification of ability to wear a negative pressure regulator.

FEDERAL FACILITIES DIVISION
NEW HEATING AND REFRIGERATION PLANT
UTILITY SYSTEMS REPAIRER OPERATOR
PLANT OPERATOR

INTRODUCTION

The incumbent is assigned to rotating shift work and performs all operating and preventive maintenance tasks related to boilers, chillers, and auxiliaries as directed by the Shift Foreman. The position is located in the Pentagon New Heating and Refrigeration Plant (NHRP). The plant is responsible for the production of steam and chilled water as well as the disposal of sewage. The plant generates high pressure steam and chilled water to supply the heating and cooling needs of the Pentagon, Navy Annex [Federal Office Building (FOB) 2], and Marine Corps Headquarters (Henderson Hall). The Pentagon Sewage Pump Station handles sewage from the Pentagon, FOB 2, and Arlington National Cemetery. The plant is in operation on a continuous, year-round basis and provides services to personnel and equipment essential to national defense.

Until the NHRP, which is currently under construction, becomes operational, the Plant Operator will participate in equipment and system reviews, training, walkdowns, start-up, and testing to become fully qualified at the time of turnover.

MAJOR DUTIES

Operates all boilers, chillers, and emergency power equipment, including all pumps, fans, diesel generators, and auxiliary plant equipment; operates, starts, and shuts down equipment, as directed by the Shift Foreman and as required for proper operation, using computer controls in the control room, local digital controls in the equipment rooms, or fully manual controls on or near the equipment. Operates the computer system to observe equipment readings and systems parameters. Recognizes abnormal conditions and situations from computer screens, alarms, and printouts; knows procedures to follow to restore the systems to a safe condition. Typical major systems that must be operated under normal and emergency operating conditions include steam, condensate, boiler, feedwater, condenser water, multiple fuel systems, ion exchange softeners, compressed air, chemical feed, and soot blowing. Performs preventive maintenance on the same systems without supervision. When necessary, observes and records readings of indicating instruments.

Makes inspection tours during the assigned shift to check the operating conditions of plant equipment, gauges, charts, and records, and to make certain that all equipment is operating satisfactorily and is loaded efficiently and safely. Makes changes necessary for good operation, reporting abnormal conditions and unusual situations to the Shift Foreman.

Inspects mechanical and electrical equipment in and out of service to check the status of equipment. Determines causes of unusual or improper operation and operating conditions, determines causes of equipment failure, and recommends actions to prevent recurrence of improper operation or equipment failure.

Makes recommendations for improvements in operations and safety practices.

Prepares, places, or removes safety tags in accordance with established procedures, taking proper precautions and using safety equipment to ensure the safety of plant personnel and equipment.

Maintains proper chemistry of boiler and chiller water in accordance with operating instructions.

SKILL AND KNOWLEDGE

The incumbent is skilled in and knowledgeable of the theory of operation of heating, air conditioning, water, steam, condensate, refrigeration, fuel oil, and soot blowing systems. This knowledge is necessary to safely start, stop, and regulate the systems for optimum efficiency and to troubleshoot operational problems.

The incumbent holds a District of Columbia Class 1 Steam Engineer License or an equivalent license (such as a marine engineering license), or has a minimum of five years experience in the operation of a steam and chiller plant, three years of which were as an operator performing start-up and shutdown of major and auxiliary equipment without direct supervision. This provides evidence of practical experience in plant operations

The incumbent is skilled in the kind and quality of materials and equipment to be used in performing various checks, tests, adjustments, and troubleshooting tasks at the system level to determine the operational performance of the equipment and the need for adjustment or repair.

The incumbent has knowledge of computerized distributed process control systems, including microprocessor-based controls and instruments, operator workstations, and automatic-to-manual control protocols, and of the functioning of equipment when operating the boiler and chiller control workstations as well as the managers' workstations. The incumbent recognizes malfunctions of computer controls and knows the proper steps to take to initiate manual control. The NHRP is a fully automated plant utilizing state-of-the-art distributed process

controls and requires an understanding of and ability to use a computer, software and associated devices, including programmable logic controllers, distributed process controllers, microprocessor-based monitoring instrumentation, and other related electronic devices, in addition to the instruments and controls typically used in the operation of power plant equipment.

The incumbent has knowledge of controls of all plant systems. Using either computer or local or manual controls, the incumbent is able to put each system into operation, safely shut each system down, and isolate major components for maintenance and repairs. The incumbent understands and can performing complex system operations such as charging refrigeration systems without supervision. This knowledge is necessary because of the reduced manning level for shift operations, and considering the vulnerability of the fully automated features of the plant.

The incumbent is qualified to perform emergency first aid in the event of injuries to self or other employees and has a working knowledge of fire protection and the capabilities of fire fighting equipment.

RESPONSIBILITIES

Carries out duties assigned by the Shift Foreman. Is responsible for taking the proper steps in the operation of equipment. Checks all repairs of major equipment (boilers, chillers, pumps, air compressors, heat exchangers, etc.) before start-up of the equipment.

Carries out normal and routine duties with minimal supervision. Independently takes corrective measures in response to abnormal occurrences or malfunctions and reports such activities to the Shift Foreman as soon as practical.

Properly implements operating procedures following established work practices. Applies judgment, based on experience, to handle abnormal situations. Recognizes emergency situations and initiates immediate corrective actions to prevent or minimize unsafe consequences.

Under direct or general supervision, regularly and customarily assumes full responsibilities for complete remote operation of the plant from a central control room.

Takes responsibility, when assigned, for supervising a crew in completing repairs, including assigning work, issuing maintenance instructions, requisitioning materials and tools, and inspecting the job.

Follows the plant safety rules and practices, and develops safe working practices.

Maintains work area and equipment in a clean, orderly condition.

Follows the plant procedures and good practices for the efficient and economical use, care, and handling of operating tools, and supplies.

PHYSICAL EFFORT

Work involves significant walking, standing, bending, stooping, crawling, climbing of ladders, use of tools, and lifting of heavy items to inspect equipment, perform repairs, or correct problems.

WORKING CONDITIONS

The incumbent works in operating equipment areas inspecting the steam generation plant, refrigeration plant, sewage pumping station, steam tunnels, manholes, etc. The operating areas are noisy, hot or cold, and dirty, and they contain moving equipment and pressurized piping systems, which can be hazardous if improperly operated. The plant contains hazardous chemicals that require special handling procedures and protection. Conditions require that appropriate safety gear such as hard hats, protective eye wear, and gloves be worn.

The incumbent must pass a physical examination annually with medical certification of ability to wear a negative pressure regulator.

FEDERAL FACILITIES DIVISION
NEW HEATING AND REFRIGERATION PLANT
UTILITY SYSTEMS REPAIRER OPERATOR
REPAIR MECHANIC

INTRODUCTION

The incumbent is assigned to rotating shift work and performs all operating and maintenance tasks related to boilers, chillers, and auxiliaries as directed by the General Foreman or Shift Foreman. The incumbent shall be qualified to operate plant equipment using computer controls.

The position is located in the New Heating and Refrigeration Plant (NHRP). The plant is responsible for the production of steam and chilled water as well as the disposal of sewage. The plant generates high pressure steam and chilled water to supply the heating and cooling needs of the Pentagon, Navy Annex [Federal Office Building (FOB) 2], and Marine Corps Headquarters (Henderson Hall). The Pentagon Sewage Pump Station handles sewage from the Pentagon, FOB 2, and Arlington National Cemetery. The plant is in operation on a continuous, year-round basis and provides services to personnel and equipment essential to national defense.

Until the NHRP, which is currently under construction, becomes operational, the Repair Mechanic will participate in equipment and system reviews, training, walkdowns, start-up, and testing to become fully qualified at the time of turnover.

MAJOR DUTIES

Performs corrective and preventive maintenance on boilers, chillers, and emergency power equipment. Maintains, tests, troubleshoots, and repairs mechanical equipment including boiler tubes and drums, burners, flame safety equipment, chemical feed devices, valves, gauges, pumps, fans, sluice gates, traveling screens, heat exchangers, air compressors, fuel oil tanks, chiller compressors, sewage communicator, diesel engines, and auxiliary plant equipment.

Removes and reinstalls components using established rigging practices.

Operates, starts, and shuts down equipment, as directed by the Shift Foreman and as required for proper operation, using computer controls in the control room, local digital controls in the equipment rooms, or fully manual controls on

or near the equipment. Operates the computer system to observe equipment readings and systems parameters. Recognizes abnormal conditions and situations from computer screens, alarms, and printouts; knows procedures to follow to restore the systems to a safe condition. Typical major systems that must be operated under normal and emergency operating conditions include steam, condensate, boiler, feedwater, condenser water, multiple fuel systems, ion exchange softeners, compressed air, chemical feed, and soot blowings. When necessary, observes and records readings of indicating instruments.

Makes inspection tours during the assigned shift to check the operating conditions of plant equipment, gauges, charts, and records, and to make certain that all equipment is operating satisfactorily and is loaded efficiently and safely. Makes changes necessary for good operation, reporting abnormal conditions and unusual situations to the Shift Foreman.

Inspects mechanical and electrical equipment in and out of service to check the status of equipment. Determines causes of unusual or improper operation and operating conditions, determines causes of equipment failure, and recommends actions to prevent recurrence of improper operation or equipment failure.

Makes recommendations for improvements in operations and safety practices.

Prepares, places, or removes safety tags in accordance with established procedures, taking proper precautions and using safety equipment to ensure the safety of plant personnel and equipment.

SKILL AND KNOWLEDGE

The incumbent is skilled in and knowledgeable of the maintenance and operation of boilers, chillers, circulating water systems, compressed air systems, heating, air conditioning, steam distribution and condensate return systems, and fuel oil systems, as well as skilled at reading system flow diagrams and equipment maintenance drawings and instructions. Evidence of a minimum of three years experience as a millwright or lead repair mechanic in a steam generation and chiller plant is required.

The incumbent holds a District of Columbia Class 3 Steam Engineer License or an equivalent license (such as a marine engineering license), or has a minimum of three years experience in the operation of a steam and chiller plant, one year of which included start-up and shutdown of major and auxiliary equipment without direct supervision. This provides evidence of practical experience in plant operations.

The incumbent is skilled in the kind and quality of materials and equipment to be used in performing various checks, tests, adjustments, and troubleshooting tasks at the system level to determine the operational performance of the equipment and the need for adjustment or repair.

The incumbent has knowledge of computerized process control systems, including micro-processor based controls and instruments, operator workstations, and automatic-to-manual control procedures.

The incumbent has knowledge of controls of all plant systems. Using either computer or local or manual controls, the incumbent is able to put each system into operation, safely shut each system down, and isolate major components for maintenance and repairs. This knowledge is necessary because of the reduced manning level for shift operations, and considering the vulnerability of the fully automated features of the plant.

The incumbent is qualified to perform emergency first aid in the event of injuries to self or other employees and has a working knowledge of fire protection and the capabilities of fire fighting equipment.

RESPONSIBILITIES

Carries out duties assigned by the General Foreman or the Shift Foreman. Responsible for performing mechanical preventive and corrective maintenance work, taking service calls, and performing repairs or minor new construction. Checks all repairs of mechanical equipment before start-up of the equipment.

Carries out normal and routine duties with minimal supervision. Independently takes corrective measures in response to abnormal occurrences or malfunctions and reports such activities to the Shift Foreman as soon as practical.

Properly implements operating and maintenance procedures following established work practices. Applies judgment, based on experience, to handle abnormal situations. Recognizes emergency situations and initiates immediate corrective actions to prevent or minimize unsafe consequences.

Takes responsibility, when assigned, for supervising a crew in completing repairs, including assigning work, issuing maintenance instructions, requisitioning materials and tools, and inspecting the job.

Follows the plant safety rules and practices, and develops safe working practices.

Maintains work area and equipment in a clean, orderly condition.

Follows the plant procedures and good practices for the efficient and economical use, care, and handling of operating tools and supplies.

PHYSICAL EFFORT

Work involves significant walking, standing, bending, stooping, crawling, climbing of ladders, use of tools, and lifting of heavy items to inspect equipment, perform repairs, or correct problems.

WORKING CONDITIONS

The incumbent works in operating equipment areas inspecting the steam generation plant, refrigeration plant, sewage pumping station, steam tunnels, manholes, etc. The operating areas are noisy, hot or cold, and dirty, and they contain moving equipment and pressurized piping systems, which can be hazardous if improperly operated. The plant contains hazardous chemicals that require special handling procedures and protection. Conditions require that appropriate safety gear such as hard hats, protective eye wear, and gloves be worn.

The incumbent must pass a physical examination annually with medical certification of ability to wear a negative pressure regulator.

FEDERAL FACILITIES DIVISION
NEW HEATING AND REFRIGERATION PLANT
DISTRIBUTION FACILITIES ELECTRICIAN

INTRODUCTION

The incumbent is assigned to rotating shift work and performs all operating and maintenance tasks related to electrical equipment as directed by the General Foreman or Shift Foreman. The incumbent shall be qualified to operate plant equipment using computer controls. The incumbent will be called upon to repair instruments and controls if the regularly assigned instrumentation/controls mechanic is not available.

The position is located in the Pentagon New Heating and Refrigeration Plant (NHRP). The plant is responsible for the production of steam and chilled water as well as the disposal of sewage. The plant generates high pressure steam and chilled water to supply the heating and cooling needs of the Pentagon, Navy Annex [Federal Office Building (FOB) 2], and Marine Corps Headquarters (Henderson Hall). The Pentagon Sewage Pump Station handles sewage from the Pentagon, FOB 2, and Arlington National Cemetery. The plant is in operation on a continuous, year-round basis and provides services to personnel and equipment essential to national defense.

Until the NHRP, which is currently under construction, becomes operational, the Electrician will participate in equipment and system reviews, training, walkdowns, start-up, and testing to become fully qualified at the time of turnover.

MAJOR DUTIES

Operates and maintains all switchgear, feeder and distribution lines, transformers, distribution panels, circuit breakers, motor control centers, motors and emergency diesel generators. Maintains, tests, troubleshoots, and repairs electrical equipment, including power cabling, lighting systems and components, chiller and air conditioning electrical components, motor operators, solenoids, public address systems, electric overhead cranes, intrusion detection systems, electronic entry control systems, fire detection and alarm systems, station batteries and in-plant telephone systems.

Installs electrical wiring, switches, and outlet boxes. Tests electrical additions/modifications.

Operates, starts, and shuts down equipment, as directed by the Shift Foreman and as required for proper operation, using computer controls in the control room, local digital controls in the equipment rooms, or fully manual controls on or near the equipment. Operates the computer system to observe equipment readings and systems parameters. Recognizes abnormal conditions and situations from computer screens, alarms, and printouts; knows procedures to follow to restore the systems to a safe condition. Typical major systems that must be operated under normal and emergency operating conditions include steam, condensate, boiler, feedwater, condenser water, multiple fuel systems, ion exchange softeners, compressed air, chemical feed, and soot blowing. When necessary, observes and records readings of indicating instruments.

Makes inspection tours during the assigned shift to check the operating conditions of plant mechanical and electrical equipment, including meters, gauges, charts, and records, and to make certain that all equipment is operating satisfactorily. Reports abnormal conditions and unusual situations to the Shift Foreman.

Inspects, calibrates, and performs maintenance on instruments and controls. Diagnoses, tests, and repairs malfunctioning instruments and controls, on-site or in the workshop.

Inspects mechanical and electrical equipment in and out of service to check the status of equipment. Determines causes of unusual or improper operation and operating conditions of electrical equipment, determines causes of equipment failure, and recommends actions to prevent recurrence of improper operation or equipment failure.

Makes recommendations for improvements in operations and safety practices.

Prepares, places, or removes safety tags in accordance with established procedures, taking proper precautions and using safety equipment to ensure the safety of plant personnel and equipment.

SKILL AND KNOWLEDGE

The incumbent is skilled in and knowledgeable of the theory of operation of electrical equipment, including switchgear, transformers, controls, relays, circuit breakers, fuses, motors, and generators necessary to operate and maintain the equipment and to troubleshoot operational problems. The incumbent is skilled at reading wiring diagrams. Evidence of a minimum of three years experience as a journeyman electrician is required.

The incumbent is familiar with the National Electrical Code and can interpret the code to determine proper wire size, types of enclosures, and insulating values of commonly used materials.

The incumbent holds a District of Columbia Class 3 Steam Engineer license or an equivalent license (such as a marine engineering license), or has a minimum of three years experience in the operation of a steam and chiller plant, one year of which included start-up and shutdown of major and auxiliary equipment without direct supervision. This provides evidence of practical experience in plant operations.

The incumbent is skilled in the kind and quality of materials and equipment to be used in performing various checks, tests, adjustments, and troubleshooting tasks at the system level to determine the operational performance of the equipment and the need for adjustment or repair.

The incumbent has knowledge of computerized process control systems, including microprocessor-based controls and instruments, operator workstations, and automatic-to-manual control procedures.

The incumbent has knowledge of controls of all plant systems. Using either computer or local or manual controls, the incumbent is able to put each system into operation, safely shut each system down, and isolate major components for maintenance and repairs. This knowledge is necessary because of the reduced manning level for shift operations, and considering the vulnerability of the fully automated features of the plant.

The incumbent is skilled in the use of analog and digital equipment and of special instruments and tools for calibrating and testing sensitive devices. The incumbent will be called upon to repair/restore controls and instruments in situations when instrumentation/controls mechanics are not available.

The incumbent is qualified to perform emergency first aid in the event of injuries to self or other employees and has a working knowledge of fire protection and the capabilities of fire fighting equipment.

RESPONSIBILITIES

Carries out duties assigned by the General Foreman or the Shift Foreman. Is responsible for performing electrical preventive and corrective maintenance work, taking service calls, and performing repairs or minor new construction. Checks all repairs of electrical equipment before start-up of the equipment.

Carries out normal and routine duties with minimal supervision. Independently takes corrective measures in response to abnormal occurrences or malfunctions and reports such activities to the Shift Foreman as soon as practical.

Properly implements operating and maintenance procedures following established work practices. Applies judgment, based on experience, to handle abnormal situations. Recognizes emergency situations and initiates immediate corrective actions to prevent or minimize unsafe consequences.

Takes responsibility, when assigned, for supervising a crew in completing repairs, including assigning work, issuing maintenance instructions, requisitioning materials and tools, and inspecting the job.

Follows the plant safety rules and practices, and develops safe working practices.

Maintains work area and equipment in a clean, orderly condition.

Follows the plant procedures and good practices for the efficient and economical use, care, and handling of operating tools, and supplies.

PHYSICAL EFFORT

Work involves significant walking, standing, bending, stooping, crawling, climbing of ladders, use of tools, and lifting of heavy items to inspect equipment, perform repairs, or correct problems.

WORKING CONDITIONS

The incumbent works in operating equipment areas inspecting the steam generation plant, refrigeration plant, sewage pumping station, steam tunnels, manholes, etc. The operating areas are noisy, hot or cold, and dirty, and they contain moving equipment and pressurized piping systems, which can be hazardous if improperly operated. The plant contains hazardous chemicals that require special handling procedures and protection. Conditions require that appropriate safety gear such as hard hats, protective eye wear, and gloves be worn.

The incumbent must pass a physical examination annually with medical certification of ability to wear a negative pressure regulator.

FEDERAL FACILITIES DIVISION
NEW HEATING AND REFRIGERATION PLANT
ELECTRONIC INDUSTRIAL CONTROLS
MECHANIC

INTRODUCTION

The incumbent performs all preventive and corrective maintenance and minor modifications on instruments and controls for boilers, chillers, and auxiliaries, as directed by the General Foreman. The position may require assignment to rotating shift work.

The position is located in the New Heating and Refrigeration Plant (NHRP). The plant is responsible for the production of steam and chilled water as well as the disposal of sewage. The plant generates high pressure steam and chilled water to supply the heating and cooling needs of the Pentagon, Navy Annex [Federal Office Building (FOB) 2], and Marine Corps Headquarters (Henderson Hall). The Pentagon Sewage Pump Station handles sewage from the Pentagon, FOB 2, and Arlington National Cemetery. The plant is in operation on a continuous, year-round basis and provides services to personnel and equipment essential to national defense.

Until the NHRP, which is currently under construction, becomes operational, the Electronic Industrial Controls Mechanic will participate in equipment and system reviews, training, walkdowns, start-up, and testing to become fully familiar with plant controls and instruments at the time of turnover.

MAJOR DUTIES

Performs preventive and corrective maintenance and first level diagnostics for instruments, controls, and electronic devices used in the plant systems, including boilers and chillers, pumps, fans, and auxiliary plant equipment. Instruments to be maintained and repaired include digital and analog combustion control systems; smart combustion gas analyzers; combustion air controls; feedwater system controls; electronic registers associated with the flow monitors; digital process loop controllers; programmable conductivity transmitters and programmable bar graph displays; refrigeration system controls; telephone systems; plant heating, ventilation, and air conditioning controls; data loggers; and numerous electrical, pneumatic, and hydraulic control systems and subsystems. Devices include microprocessor-based flame safety and boiler signal

transmitters; analog-to-digital (pneumatic, hydraulic, or electrical to electronic) transducers; valve positioners; ring balance meters; differential pressure transmitters; pneumatic feedback controllers; oxygen trim controllers; electronic and pneumatic temperature, pressure, and flow measuring and transmitting devices; and electronic/pneumatic graph recorders.

Inspects, calibrates, and performs maintenance and fine-tuning on instruments and controls. Diagnoses, tests, and repairs malfunctioning instruments and controls, on-site or in the workshop. Assists in the investigation of major equipment failures where instrumentation or controls may be involved.

Analyzes various control systems and makes adjustments and modifications to upgrade these systems to improve the overall reliability and efficiency of the systems as a whole. Installs new electronic devices or control instruments and determines time and material requirements in advance. Starts up and debugs newly installed devices and systems. Modifies working drawings to reflect changes made.

Reads and interprets blueprints, schematics, and manufacturers' instructions. Traces control wiring and understands ladder diagrams. Utilizes numerous types of pneumatic/electronic test instruments. Helps train lower classified employees. Collects or directs the collection and replacement of recording instrument charts. Keeps proper inventory of various charts. Recommends procurement of supplies and instruments to supervisor.

Makes recommendations for improvements in operations and safety practices.

Prepares, places, or removes safety tags in accordance with established procedures, taking proper precautions and using safety equipment to ensure the safety of plant personnel and equipment.

SKILL AND KNOWLEDGE

The incumbent has knowledge of the theory related to electronic, electrical, and pneumatic instrumentation and controls and digital equipment for industrial process applications. This knowledge is necessary for analyzing, testing, troubleshooting, repairing, and calibrating such devices and systems.

The incumbent has knowledge of computer control systems for industrial applications, including (1) configuration and operation of computer software and programming in multitask operating systems such as QNX and disk operating systems; (2) network hardware and software and communication protocols (familiarity with Bristol Standard Asynchronous Protocol is desirable); (3) fiber optic data highways; (4) communication hardware, including serial and parallel communication RS-232 and RS-485 connectors, and electronic and fiber optic modems; (5) programmable logic controllers, distributed process controllers, and ladder logic and reprogramming of ladder logic (familiarity with Bristol Babcock

ACCOL programming language is desirable); (6) 486 PC workstations and uninterruptible power supplies; and (7) microprocessor-based monitoring instrumentation including intelligent digital pressure, temperature, and level transmitters, electronic registers associated with flow monitors, digital process loop controllers, smart combustion gas analyzers, programmable conductivity transmitters and programmable bar graph displays. Knowledge of these systems and instruments is necessary because their proper functioning is essential for the safe and efficient operation of the NHRP.

The incumbent has working knowledge of central heating boiler systems and central station refrigeration systems and their operation. This knowledge is necessary to understand the process application of controls and instruments in performing maintenance and repair.

The incumbent is skilled in the use of analog and digital equipment and of special instruments and tools for calibrating and testing sensitive devices. The incumbent will be called upon to repair/restore controls and instruments requiring novel, unplanned approaches and skills derived from experience with a variety of problems.

The incumbent is qualified to perform emergency first aid in the event of injuries to self or other employees and has a working knowledge of fire protection and the capabilities of fire fighting equipment.

RESPONSIBILITIES

Carries out duties assigned by the General Foreman. Responds to requests made by shift personnel for technical assistance in the operation or repair of instruments and controls. Is responsible for taking the proper steps in the maintenance of instrumentation and controls. Checks all repairs of instruments and controls before start-up of the equipment.

Carries out normal and routine duties with minimal supervision. Independently takes corrective measures in response to abnormal occurrences or malfunctions and reports such activities to the Shift Foreman and the General Foreman as soon as practical.

Properly implements operating and maintenance procedures following established work practices. Applies judgment, based on experience, to handle abnormal situations. Recognizes emergency situations and initiates immediate corrective actions to prevent or minimize unsafe consequences.

Directs others assigned for assistance in the proper operation and maintenance of instruments and controls.

Takes responsibility, when assigned, for supervising a crew in performing tasks, including assigning work, issuing maintenance instructions, requisitioning materials and tools, and inspecting the job.

Follows the plant safety rules and practices, and develops safe working practices.

Maintains work area and equipment in a clean, orderly condition.

Follows the plant procedures and good practices for the efficient and economical use, care, and handling of operating tools, and supplies.

PHYSICAL EFFORT

Work involves significant walking, standing, bending, stooping, crawling, climbing of ladders, use of tools, and lifting of heavy items to inspect equipment, perform repairs, or correct problems.

WORKING CONDITIONS

The incumbent works in shops and operating equipment areas performing tasks near the steam generation equipment, refrigeration plant, switchgear cabinets, sewage pumping station, steam tunnels, manholes, etc. The operating areas are noisy, hot or cold, and dirty, and they contain moving parts, high voltage equipment, and pressurized piping systems, which can be hazardous if improperly operated. The plant contains hazardous chemicals that require special handling procedures and protection. Conditions require that appropriate safety gear such as hard hats, protective eye wear, and gloves be worn.

The incumbent must pass a physical examination annually with medical certification of ability to wear a negative pressure regulator.

APPENDIX D

Facility Survey Results

Facility Survey Results

In an attempt to benchmark the staffing proposed for the NHRP, we contacted eight other facilities to determine their staffing levels, the types of equipment they operate, and their experiences. The facilities included those with boilers of the same manufacturer as those for the NHRP. Four of the facilities are in the private sector (two universities, one industrial plant, and one large hotel) and four are in the Federal government (three military bases and the General Services Administration Heating Operation and Transmission District plants in Washington, D.C.). Table D-1 summarizes the survey results.

With the exception of the GSA-HOTD plants, the staffing levels at all of the facilities are quite low — one to three operators per shift and modest numbers of repair personnel. The total number of staff is relatively small whether the plant is simple, consisting primarily of a few steam heating boilers, or a more complex commercial facility.

The staffing levels at the two GSA-HOTD plants — 60 to 70 personnel at each — closely resemble the staffing level at the PUP. The equipment at the GSA-HOTD plants, like that at the PUP, is old, but most of the boilers have been fitted with modern digital controls at local stations.

Although the staffing levels found in our limited survey vary considerably, we conclude that modern, well-designed plants with computerized controls can be staffed with relatively few personnel, particularly when loss of services can be tolerated. Since the services provided by the NHRP are essential, we believe that its staffing level should be somewhat higher than that in a comparable facility. A staffing level of 35 to 40 personnel for the NHRP is reasonable to ensure continuity of service.

Table D-1.
Summary of Survey Results

Facility/ location	Contact/ Tel. No.	Date	Equipment	Staffing	Experience
NASA Hampton, VA	Dan McGowan 804-864-4493	6/10/94	Three older boilers in service; new English boiler (50,000 lb/hr), scheduled for start-up 6/27/94, equipped with Southern burner and Bristol controls. Gas is primary fuel.	Two operators/shift – 2nd operator serves as relief in case of call-ins; essentially have only 1 on watch; have a total of 5 operators. Two people on maintenance: 1 is assigned to remote boilers and the other to plant and tunnels.	English-Southern converted 1 boiler to gas firing — "did a good job." Have Johnson-Yagama digital controls on existing boilers, and these work very well. Controls are very simple and training is on-the-job. Servicing of instruments and controls is by contractor. Fisher-Monican feedwater control valves and single loop controls work well. A full system shutdown is taken annually to work on steam distribution line; repair effort for maintenance and during start-up is heavy, but tapers down.
Ft. Greely Fairbanks, AK	George Pursey 907-873-4570	6/10/74	Two English boilers (50,000 lb/hr) with Coen burners – No. 1 Artic diesel fuel; Brandon controls. Five diesel generators.	One operator on evening shift (3 p.m. to 7 a.m.) but need two. Eight operators on day shift.	Happy with boilers, believes a bigger drum would be better. Plenty of capacity. Had some problems with high skin (casing temperature – 150F – but this was fixed. Still shaking down the Brandon controls; problems appear to be related to lack of experience of Brandon personnel. Have speed control problems on FD fan and oxygen problems at low firing rates. Training is on-the-job.

Table D-1.
Summary of Survey Results

Facility/ location	Contact/ Tel. No.	Date	Equipment	Staffing	Experience
James Madison University Harrisonburg, VA	Ronald Shifflet 703-578-6211	6/13/94	One Keeler and one B&W boiler, each 25,000 lb/hr; new English boiler (44,000 lb/hr), 1 year old. Coen controls. Gas fired.	One operator per shift; total of 6 operators with 1 person serving as backup and performing maintenance. Superintendent would prefer 2 additional people to handle problems.	New English boiler works well. Have a lot of problems with diesel controls and Foxboro regulators for feedwater valve and air damper. Servicing of controls is performed under contract to ACI. Controls are somewhat complicated, and it takes several months for the average operator to become proficient. Start-up training was provided by Coen for the first few weeks of initial operation.
Opreyland Hotel Nashville, TN	Ray Potts 615-889-1000 ext. 2828	6/13/94	One English boiler (80,000 lb/hr), 2 months in operation. Gas fired with No. 2 oil backup. Detroit Burner controls. Newly installed waste heat recovery boiler taking exhaust from a 5 MW Solar gas turbine. One absorption chiller (1,000 ton), 4 new centrigugal chillers (1,400 ton, 4,160-V motors), 2 older chillers (100 ton, 480-V motors).	One operator on 2nd and 3rd (back) shifts, 2 on days. Currently have 30 people in O&M department, expect to add 15 more; maintenance personnel also responsible for distribution system, plumbing, ice machines, etc. (3,000 rooms). Emphasis placed on cross training so that personnel can perform maintenance and operate all equipment. Existing personnel learned new controls fairly easily.	Boiler and controls are performing well. Gas turbine and waste heat recovery boiler still undergoing testing. Total energy management system will be evaluated in the next few months. On-site controls service and start-up testing provided by Control Systems International of Dallas.

Table D-1.
Summary of Survey Results

Facility/ location	Contact/ Tel. No.	Date	Equipment	Staffing	Experience
Henry Vogt Machine Co. Louisville, KY	Tom Wessling 502-635-3420	6/13/94	Two English boilers (80,000 lb/hr each), 18 months in operation. Low-fire burners installed 4 months ago for low load summer operation (pilot wouldn't stay lit at low loads with the original burners). Other equipment includes plant air compressors, distribution piping, space heaters, etc.	Two pipefitters per shift check the boilers; routine is to take some readings and check the equipment twice per shift. Pipefitters are assigned maintenance duties in the plant. Boilers are unmanned. Transition to new boilers was a significant change; several months were required to train the personnel.	No problems found with boilers and controls, especially with new low fire burners. System runs on its own. Seven control alarms are located in security, and pipefitters are paged if alarms sound. Servicing performed by Coen at regularly scheduled intervals.
Navy Yard Washington, DC	Adam Wolfe	3/4/94	Two boilers (85,000 lb/hr each), undergoing start-up testing. Primary fuel is natural gas with No. 2 oil as backup. Older existing boilers in operation have a capacity of 300,000 lb/hr.	Current staff includes 8 operators and 1 operator's helper plus 3 maintenance personnel. Only 1 operator per shift is needed to operate the boilers; may be overstaffed.	
Georgetown University Washington, DC	Victor Podbielski 202-687-7416	6/13/94	Current plant: 2 gas-fired and 1 coal-fired atmospheric fluidized-bed boiler (100,000 lb/hr each); steam absorption chillers (6,000 tons total). Proposed cogeneration plant: dual-fuel combustion turbine (60 MW) with heat recovery steam generator (225,000 lb/hr). Additional chillers (3,000 tons). Fluidized-bed boiler would be retired.	Recently dropped from 32 to 26 people; most maintenance and repairs are performed in-house. Staffing proposed for new plant totals about 23 people, including 3 operators per shift (1 supervisor, 1 boiler operator, 1 chiller operator), 1 station manager, 1 clerk, 1 instrument technician, 1 electrician, and about 4 maintenance people.	

Table D-1.
Summary of Survey Results

Facility/ location	Contact/ Tel. No.	Date	Equipment	Staffing	Experience
Central Heating and Refrigeration Plant and West Heating Plant, Heating Operations and Transmission District, General Services Administration Washington, DC	Al Cacanindin 202-755-9820	6/14/94	Central Plant: 6 boilers – 2 being rebuilt (180,000 lb/hr) and 4 operational (2 rated at 400,000 lb/hr and 2 at 220,000 lb/hr). Primary fuel is natural gas with No. 6 oil as backup for the 4 operating boilers; the boilers being rebuilt can be coal stoker fired but primary fuel will be natural gas. Five electric drive chillers (11,500 tons total). Plant air compressors (1,150 scfm). Four 13.2-kV electrical feeders. Boilers 3 and 4 fitted with Bailey System 90 digital controls. Boilers 5 and 6 equipped with Hagan analog controls. West Plant: 5 boilers (220,000 lb/hr each). Primary fuel is natural gas; 3 can burn coal and 2 can burn No. 6 fuel oil. Plant air compressors. Three 13.2-kV electrical feeders. All boilers fitted with Bailey System 90 digital controls within past 3 years. Steam distribution system: 5-1/2 miles of tunnels (cross section is 7 ft. by 6 ft.), 100 manways, 60 fans, and 50 sump pumps.	The number of assigned positions at the Central and West plants are the same: 5 in administration and 76 in operations and maintenance (operations-48, mechanical maintenance-12, electrical and I&C-14, foremen-2.) Actual staffing levels are 65 at Central and 58 at West. Steam distribution system: 45 assigned positions (administration-4, pipefitters-19, insulators-12, I&C-8, foremen-2.) Actual staffing is 34.	Bailey System 90 is working well. Uses touch-screen technology. Bailey personnel provided "overview" type training during start-up. Contractor hired to debug the system and is providing some casual training. Minor control-logic problem concerns a limit on restart following boiler trip which prevents FD fans from operating for a period of 30 minutes; this is being worked on.

APPENDIX E

Training Hours by Position and System

Training Hours by Position and System

This appendix details, in Tables E-1 through E-11, the number of training hours needed for each position in the NHRP. The hours are broken down by system, module or subject, and type of training – i.e., class, walkdown, or plant.

Table E-1.
Training Plan for Plant Manager
(hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Steam generation system	Maintenance			
	Start-up, operation, and control			16
	System overview	2	2	
Condensate feedwater system	Maintenance			
	Start-up, operation, and control			16
	System overview	2	2	
Condenser water system	Maintenance			
	Start-up, operation, and control			8
	System overview	2	2	
Chiller system	Maintenance			
	Start-up, operation, and control			8
	System overview	2	2	
Chilled water distribution system	Maintenance			
	Start-up, operation, and control			8
	System overview	2	2	
Central distributed control system	Maintenance			
	Start-up, operation, and control	20		20
	System overview	2	2	
Electrical distribution systems	Maintenance			
	Start-up, operation, and control	4		12
	System overview	2	2	
Intrusion detection systems	Maintenance			
	Start-up and operation			28
	System overview			
Electronic entry control system	Maintenance			
	Start-up and operation			52
	System overview			

Table E-1.
Training Plan for Plant Manager (hours) (Continued)

System	Module	Class	Walkdown	Plant
Plant paging system	Maintenance Start-up and operation System overview			8
Fire detection and alarm system	Maintenance Start-up and operation System overview			24
Totals		42	18	200

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-2.
Training Plan for Operations and Maintenance Manager (hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Steam generation system	Maintenance			16
	Start-up, operation, and control			16
	System overview	2	2	
Condensate feedwater system	Maintenance	4		16
	Start-up, operation, and control			16
	System overview	2	2	
Condenser water system	Maintenance			
	Start-up, operation, and control			8
	System overview	2	2	
Chiller system	Maintenance			
	Start-up, operation, and control			8
	System overview	2	2	
Chilled water distribution system	Maintenance			
	Start-up, operation, and control			8
	System overview	2	2	
Central distributed control system	Maintenance			
	Start-up, operation, and control	20		20
	System overview	2	2	
Electrical distribution systems	Maintenance			
	Start-up, operation, and control	4		12
	System overview	2	2	
Compressed air equipment	Maintenance			
	Start-up, operation, and control			2
	System overview			
Sewage treatment center	Maintenance			
	Start-up, operation, and control			4
	System overview			

Table E-2.
Training Plan for Operations and Maintenance Manager (hours) (Continued)

System	Module	Class	Walkdown	Plant
Forced hot water heating system	Maintenance Start-up, operation, and control System overview			8
Central air conditioning	Maintenance Start-up, operation, and control System overview			4
Air supply distribution system	Maintenance Start-up, operation, and control System overview			20
Ventilation and exhaust system	Maintenance Start-up, operation, and control System overview			12
HVAC control	Maintenance Start-up, operation, and control System overview			16
Hydraulic elevators	Maintenance Start-up, operation, and control System overview			4
Electric overhead traveling cranes	Maintenance Start-up, operation, and control System overview			4
Monorail and hoist systems	Maintenance Start-up, operation, and control System overview			4
Intrusion detection systems	Maintenance Start-up, operation, and control System overview			28

Table E-2.
Training Plan for Operations and Maintenance Manager (hours) (Continued)

System	Module	Class	Walkdown	Plant
Electronic entry control system	Maintenance Start-up, operation, and control System overview			52
Plant paging system	Maintenance Start-up, operation, and control System overview			8
Fire detection and alarm system	Maintenance Start-up, operation, and control System overview			24
Totals		46	18	310

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-3.
Training Plan for Computer Systems Specialist (hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Steam generation system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Condensate feedwater system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Condenser water system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Chiller system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Chilled water distribution system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Central distributed control system	Maintenance			16
	Start-up, operation, and control	20		20
	System overview	2	2	
Electrical distribution systems	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Totals		38	18	36

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-4.
Training Plan for Shift Foreman
(hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Steam generation system	Maintenance			16
	Start-up, operation, and control			16
	System overview	2	2	
Condensate feedwater system	Maintenance	4		16
	Start-up, operation, and control			16
	System overview	2	2	
Condenser water system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chiller system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chilled water distribution system	Maintenance	2		6
	Start-up, operation, and control			8
	System overview	2	2	
Central distributed control system	Maintenance			
	Start-up, operation, and control	20		20
	System overview	2	2	
Electrical distribution systems	Maintenance	4		12
	Start-up, operation, and control	4		12
	System overview	2	2	
Compressed air equipment	Maintenance			
	Start-up, operation, and control			2
	System overview			
Sewage and sump pumps	Maintenance			
	Start-up, operation, and control			4
	System overview			

Table E-4.
Training Plan for Shift Foreman
(hours)

System	Module	Class	Walkdown	Plant
Forced hot water heating system	Maintenance Start-up, operation, and control system overview			8
Central air conditioning	Maintenance Start-up, operation, and control System overview			4
Air supply distribution system	Maintenance Start-up, operation, and control System overview			20
Ventilation and exhaust system	Maintenance Start-up, operation, and control System overview			12
HVAC control	Maintenance Start-up, operation, and control System overview			16
Hydraulic elevators	Maintenance Start-up, operation, and control System overview			4
Electric overhead traveling cranes	Maintenance Start-up, operation, and control System overview			4
Monorail and hoist systems	Maintenance Start-up, operation, and control System overview			4
Intrusion detection systems	Maintenance Start-up, operation, and control System overview			28

Table E-4.
Training Plan for Shift Foreman
(hours)

System	Module	Class	Walkdown	Plant
Electronic entry control system	Maintenance Start-up, operation, and control System overview			52
Plant paging system	Maintenance Start-up, operation, and control System overview			8
Fire detection and alarm system	Maintenance Start-up, operation, and control System overview			24
Totals		60	18	336

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-5.
Training Plan for Control Operator
(hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Steam generation systems	Maintenance			
	Start-up, operation, and control			16
	Systems overview	2	2	
Condensate feedwater systems	Maintenance			
	Start-up, operation, and control			16
	System overview	2	2	
Condenser water system	Maintenance			
	Start-up, operation, and control			8
	System overview	2	2	
Chiller system	Maintenance			
	Start-up, operation, and control			8
	System overview	2	2	
Chilled water distribution system	Maintenance			
	Start-up, operation, and control			8
	System overview	2	2	
Central distributed control system	Maintenance			
	Start-up, operation, and control	20		20
	System overview	2	2	
Electrical distribution systems	Maintenance			
	Start-up, operation, and control	4		12
	System overview	2	2	
Compressed air equipment	Maintenance			
	Start-up, operation, and control			2
	System overview			

Table E-5.
Training Plan for Control Operator (hours) (Continued)

System	Module	Class	Walkdown	Plant
Sewage and sump pumps	Maintenance Start-up, operation, and control System overview			4
Forced hot water heating system	Maintenance Start-up, operation, and control System overview			8
Central air conditioning	Maintenance Start-up, operation, and control System overview			4
Air supply distribution system	Maintenance Start-up, operation, and control System overview			20
Ventilation and exhaust system	Maintenance Start-up, operation, and control System overview			12
HVAC control	Maintenance Start-up, operation, and control System overview			16
Hydraulic elevators	Maintenance Start-up, operation, and control System overview			4
Electric overhead traveling cranes	Maintenance Start-up, operation, and control System overview			4
Monorail and hoist systems	Maintenance Start-up, operation, and control System overview			4

Table E-5.
Training Plan for Control Operator (hours) (Continued)

System	Module	Class	Walkdown	Plant
Intrusion detection systems	Maintenance			24
	Start-up, operation, and control			28
	System overview			
Electronic entry control system	Maintenance			
	Start-up, operation, and control			52
	System overview			
Plant paging system	Maintenance			
	Start-up, operation, and control			8
	System overview			
Totals		42	18	278

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-6.
Training Plan for Electronics Industrial Controls Mechanic (hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Steam generation system	Maintenance			16
	Start-up, operation, and control			16
	System overview	2	2	
Condensate feedwater system	Maintenance	4		16
	Start-up, operation, and control			16
	System overview	2	2	
Condenser water system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chiller system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chilled water distribution system	Maintenance	2		6
	Start-up, operation, and control			8
	System overview	2	2	
Central distributed control system	Maintenance			16
	Start-up, operation, and control	20		20
	System overview	2	2	
Electrical distribution systems	Maintenance	4		12
	Start-up, operation, and control	4		12
	System overview	2	2	
Central air conditioning	Maintenance			4
	Start-up, operation, and control			
	System overview			
Air supply distribution system	Maintenance			20
	Start-up, operation, and control			
	System overview			

Table E-6.
Training Plan for Electronics Industrial Controls Mechanic (hours) (Continued)

Summary	Module	Class	Walkdown	Plant
Ventilation and exhaust system	Maintenance			12
	Start-up, operation, and control			
	System overview			
HVAC control	Maintenance			16
	Start-up, operation, and control			
	System overview			
Hydraulic elevators	Maintenance			
	Start-up, operation, and control			4
	System overview			
Intrusion detection system	Maintenance			24
	Start-up, operation, and control			28
	System overview			
Electronic entry control system	Maintenance			40
	Start-up, operation, and control			52
	System overview			
Plant paging system	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Fire detection and alarm system	Maintenance			17
	Start-up, operation, and control			12
	System overview			
Totals		60	18	399

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-7.
Training Plan for General Foreman
(hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant Description	4	4	
Steam generation system	Maintenance			16
	Start-up, operation, and control			16
	System overview	2	2	
Condensate feedwater system	Maintenance	4		16
	Start-up, operation, and control			16
	System overview	2	2	
Condenser water system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chiller system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chilled water distribution system	Maintenance	2		6
	Start-up, operation, and control			8
	System overview	2	2	
Central distributed control system	Maintenance			
	Start-up, operation, and control	20		20
	System overview	2	2	
Electrical distribution systems	Maintenance	4		12
	Start-up, operation, and control	4		12
	System overview	2	2	
Compressed Air Equipment	Maintenance			2
	Start-up, operation, and control			2
	System overview			
Sewage and sump pumps	Maintenance			4
	Start-up, operation, and control			4
	System overview			

Table E-7.
Training Plan for General Goreman (hours) (Continued)

System	Module	Class	Walkdown	Plant
Forced hot water heating system	Maintenance			8
	Start-up, operation, and control			8
	System overview			
Central air conditioning	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Air supply distribution system	Maintenance			20
	Start-up, operation, and control			20
	System overview			
Ventilation and exhaust system	Maintenance			12
	Start-up, operation, and control			12
	System overview			
HVAC control	Maintenance			16
	Start-up, operation, and control			16
	System overview			
Hydraulic elevators	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Electric overhead traveling cranes	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Monorail and hoist systems	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Intrusion detection systems	Maintenance			24
	Start-up, operation, and control			28
	System overview			

Table E-7.
Training Plan for General Foreman (hours) (Continued)

System	Module	Class	Walkdown	Plant
Electronic entry control system	Maintenance			40
	Start-up, operation, and control			52
	System overview			
Plant paging systems	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Fire detection and alarm system	Maintenance			12
	Start-up, operation, and control			12
	System overview			
Totals		60	18	478

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-8.
Training Plan for Repair Mechanic
(hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Steam generation system	Maintenance			16
	Start-up, operation, and control			16
	System overview	2	2	
Condensate feedwater system	Maintenance	4		16
	Start-up, operation, and control			16
	System overview	2	2	
Condenser water system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chiller system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chilled water distributed system	Maintenance	2		6
	Start-up, operation, and control			8
	System overview	2	2	
Central distributed control system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Electrical distribution systems	Maintenance			
	Start-up, operation, and control	4		12
	System overview	2	2	
Compressed air equipment	Maintenance			2
	Start-up, operation, and control			2
	System overview			
Sewage and sump pumps	Maintenance			4
	Start-up, operation, and control			4
	System overview			

Table E-8.
Training Plan for Repair Mechanic (hours) (Continued)

System	Module	Class	Walkdown	Plant
Forced hot water heating system	Maintenance			8
	Start-up, operation, and control			8
	System overview			
Central air conditioning	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Air supply distribution system	Maintenance			20
	Start-up, operation, and control			20
	System overview			
Ventilation and exhaust system	Maintenance			12
	Start-up, operation, and control			12
	System overview			
HVAC control	Maintenance			16
	Start-up, operation, and control			16
	System overview			
Hydraulic elevators	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Electric overhead traveling cranes	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Monorail and hoist systems	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Intrusion detection systems	Maintenance			24
	Start-up, operation, and control			28
	System overview			

Table E-8.
Training Plan for Repair Mechanic (hours) (Continued)

System	Module	Class	Walkdown	Plant
Electronic entry control system	Maintenance			40
	Start-up, operation, and control			52
	System overview			
Plant paging system	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Fire detection and alarm system	Maintenance			12
	Start-up, operation, and control			12
	System overview			
Totals		36	18	446

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-9.
Training Plan for Pipefitter-Welder
(hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Steam generation system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Condensate feedwater system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Condenser water system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Chiller system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Chilled water distributed system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Central distribution control system	Maintenance			
	Operation			
	System overview	2	2	
Electrical distribution systems	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Totals		18	18	

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-10.
Training Plan for Electrician
(hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Steam generation system	Maintenance			16
	Start-up, operation, and control			16
	System overview	2	2	
Condensate feedwater system	Maintenance	4		16
	Start-up, operation, and control			16
	System overview	2	2	
Condenser water system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chiller system	Maintenance	4		4
	Start-up, operation, and control			8
	System overview	2	2	
Chilled water distribution system	Maintenance	2		6
	Start-up, operation, and control			8
	System overview	2	2	
Central distributed control system	Maintenance			
	Start-up, operation, and control			
	System overview	2	2	
Electrical distribution systems	Maintenance	4		12
	Start-up, operation, and control	4		12
	System overview	2	2	
Compressed air equipment	Maintenance			2
	Start-up, operation, and control			2
	System overview			
Sewage and sump pumps	Maintenance			4
	Start-up, operation, and control			4
	System overview			

Table E-10.
Training Plan for Electrician (hours) (Continued)

System	Module	Class	Walkdown	Plant
Forced hot water heating system	Maintenance			8
	Start-up, operation, and control			8
	System overview			
Central air conditioning	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Air supply distribution system	Maintenance			20
	Startup, Operation & Control			20
	System overview			
Ventilation and exhaust system	Maintenance			12
	Startup, Operation & Control			12
	System overview			
HVAC control	Maintenance			16
	Start-up, operation, and control			16
	System overview			
Hydraulic elevators	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Electric overhead traveling cranes	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Monorail and hoist systems	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Intrusion Detection Systems	Maintenance			24
	Start-up, operation, and control			28
	System overview			

Table E-10.
Training Plan for Electrician (hours) (Continued)

System	Module	Class	Walkdown	Plant
Electronic entry control system	Maintenance			40
	Start-up, operation, and control			52
	System overview			
Plant paging system	Maintenance			4
	Start-up, operation, and control			4
	System overview			
Fire detection and alarm system	Maintenance			12
	Start-up, operation, and control			12
	System overview			
Totals		40	18	458

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.

Table E-11.
Training Plan for Administrative Staff
(hours)

System	Module	Class	Walkdown	Plant
General arrangement	Plant description	4	4	
Totals		4	4	

Notes: Class = structured study in classroom led by an instructor; walkdown = form of job performance measure and involves training on specific tasks utilizing a checklist indicating critical evolutions and required actions; plant = operation of equipment or repair of equipment under the guidance of a qualified person.